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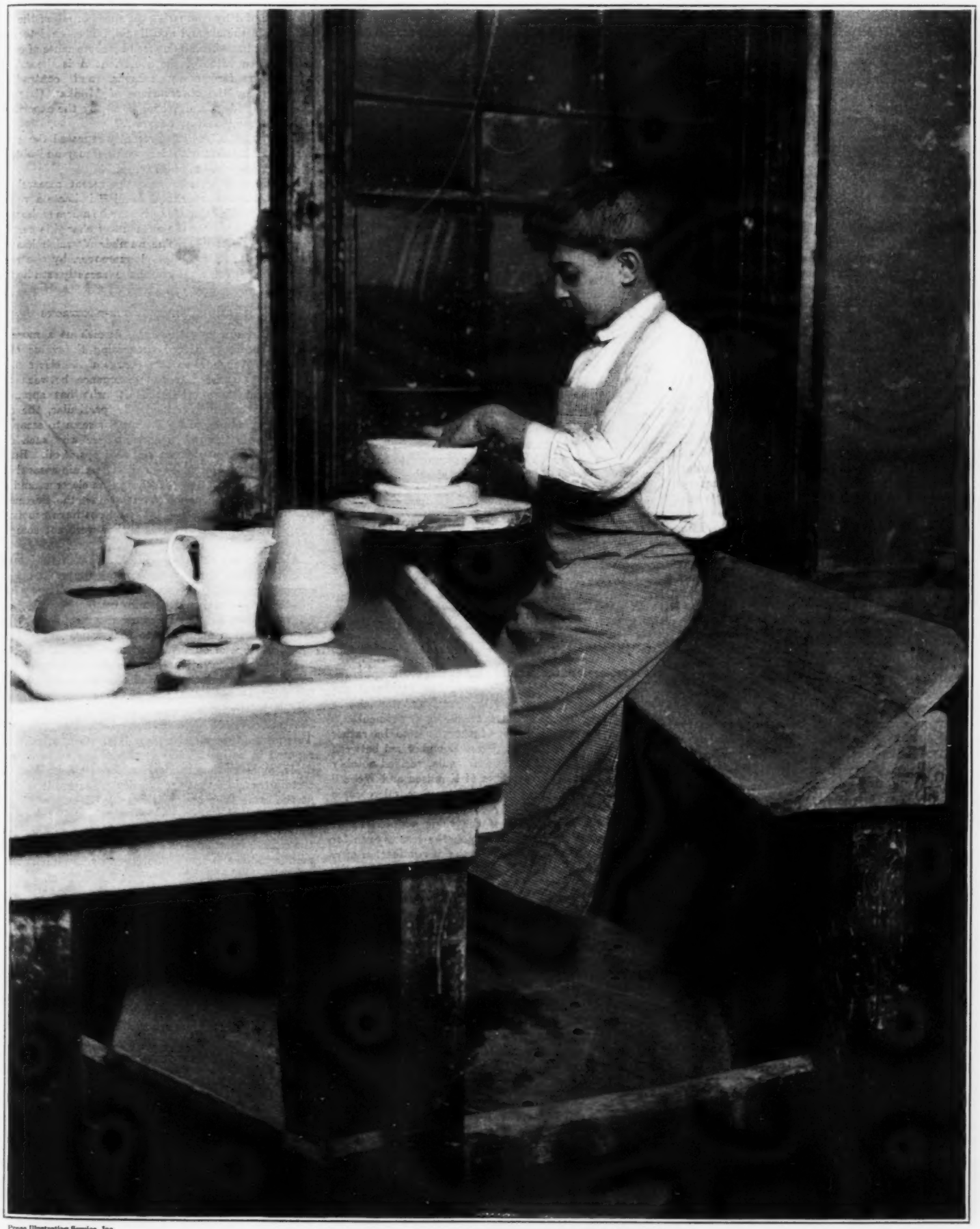

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TEACHING CHILDREN TO BE USEFUL [See page 328]

The Brownian Movement of Electrified Particles in Gases—I*

And the Charge of the Electron

By Dr. A. Schidlof

A PROBLEM of purely scientific nature which seems at present to be rousing considerable interest among physicists, is that of the exact determination of the number of Avogadro, *i. e.*, of the number of molecules contained in the molecular mass of a simple body. After the brilliant work, to-day classic, of M. Jean Perrin,[1] the question might seem to have been solved. It is nothing of the kind. The figure obtained by the direct counting of the spherules of gamboge in suspension in a liquid and by the observation of their Brownian movement is considerably greater than that which results from the study of the dark radiation. It was necessary, however, that two methods, theoretically equally well founded and almost equally precise should lead to concordant results to permit us to believe in a confirmation of the kinetic theory and in a proof of the reality of molecules.[2]

The number of Avogadro is related to another physical constant, known with very great precision, to the quantity of electricity required to liberate by electrolysis one atom-gram of a monovalent metal. We ought to have:

1. $Ne = 2.895 \times 10^{14}$ electrostat units, N representing the number of Avogadro and e the charge of the monovalent electrolytic ion. But if we introduce the hypothesis, justified by the enormous majority of established facts, that this charge is a universal constant, we can utilize the value of the elementary charge of the gaseous ions, or that of the electron, known at present with a very great precision, from the calculation of the number N We thus find:

2. $N = 6.06 \times 10^{23}$, a number considerably inferior to

3. $N = 6.85 \times 10^{23}$, which results from M. Perrin's researches.

This discord would in itself be important enough to shake our confidence in the bases of the molecular theory, but the determinations of the elementary charge e lead to divergences far more striking. While on the one hand observations made by means of spherules of oil, of mercury, and of gum-lac held in suspension in a gas furnish remarkably concordant numbers leading to the value (2) of the number of Avogadro, which accords, moreover, with the figure deduced from the study of the dark radiation, J. Roux,[3] in effecting exactly the same observations by the aid of globules of super-heated liquid sulphur, obtained a result which seems to confirm the value (3) indicated by M. Perrin.

Finally, F. Ehrenhaft[4] and many other observers, who have utilized for the same object metallic particles produced in the voltaic arc, arrive at entirely different results.

These authors deny the existence of an elementary charge and believe that the quantity of electricity borne by a spherule diminishes indefinitely with the radius or with the electric capacity of the spherule.[5]

M. Perrin[6] has objected with justice to the conclusions of M. Ehrenhaft that his whole argument rests upon the supposition that the particles are spherical in form—a supposition which is not justified by any experimental proof. M. Ehrenhaft has essayed to reply to this objection by repeating the same experiments with particles of mercury, pulverized in the same way in the voltaic arc; these, by reason of their liquid state, must necessarily take a spherical form. This same savant, and one of his pupils, D. Konstantinowsky[7] have furthermore studied the Brownian movement of their particles (particles of mercury and of gold). This study leads them to deny the laws of the Brownian movement established by Einstein,[8] which form the foundation of the researches of M. Perrin. Thus the very bases of the molecular theory are eluding us, and the whole edifice is crumbling.

On the contrary, the researches of H. Fletcher[9] and of C. F. Eyring[10] upon the Brownian movement in gases, effected by means of drops of oil, confirm, with some theoretic divergences of slight importance,[11] the theory of Einstein, and tend towards acceptance of the value (3) of the number of Avogadro, which accords with the result of the best determinations of the elementary charge.

Having had occasion to probe these problems in the course of experimental researches effected during recent years in the laboratory of physics of the University of Geneva, I desire in the present article to throw some light upon this collection of facts which are apparently so contradictory.

I—THE LAW OF STOKES-CUNNINGHAM

The method of direct determination of the elementary charge of gaseous ions proposed by J. J. Thomson and H. A. Wilson[12] has received happy modifications on the part of F. Ehrenhaft[13] and on the part, above all, of R. A. Millikan[14]. It is now easy to observe for hours together the same charged particle, held in suspension in a gas between the two plates of a condenser, by opposing to the action of gravity an electric field of suitable intensity. If we determine on the one hand the speed of the fall of the particle, in obedience to the action of its weight, and on the other hand its speed of ascension in an electric field of a determined intensity, we can calculate the absolute value of the charge of the particle, on condition that we know the law of the resistance offered to the movement of the particle by a gaseous medium. The hydrodynamic, law of the resistance which a fluid opposes to the movement of a sphere has been established by Stokes.[15]

The resistance is proportional to the speed, to the radius of the sphere, and to the coefficient of viscosity of the gas. However, this law does not apply to spheres of great mass whose speed limit is considerable, for in that case the resistance is not a linear function of the speed; neither does it apply to microscopic or ultra microscopic spherules.

Resistance is indeed in this case proportional to the speed, but it no longer depends exclusively on the coefficient of viscosity, and it is necessary to take into consideration in calculating the resistance elements borrowed from the kinetic theory of gases. E. Cunningham[16] has succeeded in finding a theoretic formula which comprises the same factor as the law of Stokes, divided by the quantity $1 + \frac{Al}{a}$, l being the average path of the molecule of the gas and a the radius of the spherule.

The coefficient A depends upon the nature of the shocks between the gaseous molecules and the surface of the sphere; it must be determined experimentally. According to the tendency of the shock to be rather feeble or elastic, A will have values comprised between 0.815 and 1.63. This theoretic formula, verified notably by the experimental researches of Knudsen and Weber[17] applies with much precision even to ultra microscopic spherules; this is commonly called the law of Stokes-Cunningham. The choice of the value adopted for A has a very material influence upon the result, even for the largest spherules utilized for the determination of e, but the importance of A becomes enormous for the smallest ones.

Thus, Millikan, who has observed relatively large drops, accepts in his earliest researches upon the charge of the electron the value A equals 0.815, and thus obtains:

$e = 4.891 \times 10^{-10}$ electrostat units, a figure which it was necessary later to lower to

4. $e = 4.774 \times 10^{-10}$

After having established by direct determinations the value:

5. $A = 0.875$.

If M. Roux (*l. c.*) finds with spherules of melted sulphur a figure near to 4.2×10^{-11} this is related in part to the extreme value of $A = 1.63$, which he has adopted in the calculating the charge of the spherules. It is to be noted that M. Roux has determined experimentally the value of A by comparing the speed of fall of the same spherule in the air and in a liquid, but these determinations must have been influenced by some cause of error.[18]

So high a value of the coefficient A is theoretically improbable for many reasons, and contradicted, moreover, by the observations of Millikan (*l. c.*), by those of Knudsen and Weber (*l. c.*), by the experiments of McKeehan,[19] and by our own.[20]

Finally, M. Silvey[21] has recently repeated the experiments of M. Roux with drops of mercury and obtained a much smaller value of A.

Let me mention also that the recent researches of MM. Millikan, Barber, and Ishida[22] indicate a value of A inferior to the value (5). It may be affirmed, however, that the value (4) of the elementary charge is certainly very near the truth. The number N which has been deduced from it is confirmed, moreover, by the results of different observers who have recently studied the Brownian Movement in liquids.

II—THE SUBJECT OF SUB-ELECTRONS

Recent researches, therefore, furnish us a more and more satisfactory accord concerning the value of the number of Avogadro and the charge of the electron. All the more surprising is the divergence between these results and those of Ehrenhaft, who has apparently employed the same method. In particular, the drops of mercury employed by this author seem to escape the objection of Perrin; one does not see why such drops should not be spherical as well as drops of oil. But the observations of Ehrenhaft furnish in certain cases charges which are *one twentieth* ($\frac{1}{20}$) that of an electron, and they would form a serious argument against the existence of the "atom of electricity" if we did not have proofs that the particles utilized by this author were not composed of pure mercury.

Almost simultaneously with M. Ehrenhaft, I myself, in collaboration with M. Karpowicz[23] studied the charges carried by ultra microscopic drops of mercury. But in place of pulverizing the mercury in the voltaic arc, as did Ehrenhaft, we had recourse to a mechanical process of pulverization analogous to that which has served to produce drops of oil. We had made upon this occasion the curious observation that the drops of mercury are *volatile*;[24] their durations of fall augment continually and indefinitely, and at the same time the durations of ascension diminish. But the particles of mercury observed by M. Ehrenhaft were *absolutely inevariable*. This proves that the electric pulverization, even in a gas reputed to be inert, such as nitrogen or carbonic anhydride, modifies the chemical nature of the bodies. It is certain therefore that the physical structure is subjected at the same time to important modifications. The ill-defined substance which we obtain by the electric pulverizing of mercury no longer obeys with certainty the same laws of superficial tension as a liquid. In this manner all the anomalies observed by Ehrenhaft can be very simply explained.

That electric pulverization never leads to the spherule form is made precisely evident by the experiments of E. Myer and W. Gerlach[25] upon the law of resistance of fall at different pressures, applying to the same particle of platinum produced by electric pulverization. Finally a comparative study of particles of mercury pulverized mechanically and in the voltaic arc, made by A. Targouski;[26] has made evident the profound differences which exist between the two species of minute bodies

The following table, borrowed from his memoir, permits us to perceive these differences:

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*Revue Generale des Sciences.

[1] J. Perrin: Ann. de ch. et de Phys., Sep. 1909, p. 1–114.—Les preuves de la réalité moléculaire. Soc. fr. de Phys. confrée. faites en 1912, p. 1–53.

[2] According to a recent article of Costantin in the Ann. de Phys., 1915, Vol. III, p. 101, the methods of M. Perrin may be subject to a cause of error (the influence of walls), which might lead to too high a result.

[3] J. Roux. C. R., 1911, Vol. CLII, p. 1,168; 1912, Vol. CLV, p. 1,490. Ann. de Ch. et de Phys., 1913, Vol. XXIX, p. 69.

[4] F. Ehrenhaft. Phys. Ztschr., 1910, Vol. XI., p. 490.

[5] F. Ehrenhaft. Wien. Ber. Na., Jan., 1914, Vol. CXXIII, p. 53.

[6] J. Perrin. C. R., 1911, Vol. CLII, p. 1,666.

[7] D. Konstantinowsky. Wien. Ber. IIa, 1914, Vol. CXXIII, p. 1697.

[8] A. Einstein. Ann. der Phys., 1905, Vol. XVII, p. 559; 1906, Vol. XIX, p. 371.

[9] H. Fletcher. Phys. Rev., 1911, Vol. XXXIII, p. 92. *Rodtum*, 1911, p. 279. Phys. Rev. 1914 (2), Vol. IV, p. 440.

[10] C. F. Eyring. Phys. Rev., 1915 (2), Vol. V, p. 412.

[11] Fletcher utilizes for the calculation of results a formula which is not strictly derived from the theory of Einstein, but which accords with this in close approximation.

[12] J. J. Thomson. Phil. Mag., 1898, Vol. XLVI, p. 528, 1899, Vol. XLVIII, p. 547, 1903, Vol. V, p. 346. H. A. Wilson, Ibid., 1903, Vol. V., p. 429.

[13] F. Ehrenhaft, Wien-Ber., Na., Mar. 1909, Vol. CXVIII, p. 321.

[14] R. A. Millikan, Phys. Rev., 1911, Vol. XXXII, p. 349, Ibid., 1913 (2), Vol. II, p. 109.

[15] G. Stokes. Math. and Phys. Papers, Vol. III, p. 59.

[16] E. Cunningham. Proc. Roy. Soc. London, 1910, Vol. LXXXIII, A., p. 357–365.

[17] M. Knudsen and S. Weber. Ann. der Phys., 1911, Vol. XXXVI, p. 981.

[18] We shall indicate farther on a possible cause of error concerning the globules of suifur.

[19] M. Keehan, Phys., Rev., 1911, Vol. XXXIII, p. 153.

[20] A. Schidlof and J. Morgynowska, Arch. des. Sc. Phys. et nat. (Geneva), Vol. XL, November and December 1915—A. Schidlof and A Karpowicz Ibd. vol. XLI, Feb. 1916.

[21] O. W. Silvey. Phys. Rev., 1916 (2), Vol. VII, p. 87, 106.

[22] Millikan, Barber and Ishida. Phys. Rev. 1915 (2), Vol., V, p. 334.

[23] A. Schidlof and A. Karpowicz, l. c.

[24] A. Schidlof and A. Karpowicz, C. R., June 29, 1914, Vol. CLVIII, p. 1992.

[25] E. Meyer and W. Gerlach. Arbeiten a. d., Geb. d. Phys. Math. Chem.-Ded. to Elster and Geitel, 1915.

[26] A. Targouski. Arc. d. Sc. Phys. et Nat. (Geneva) Vol. XLI. Mar. Apr. May. 1916.

MERCURY PULVERIZED MECHANICALLY	MERCURY PULVERIZED IN THE ARC
Electrons of Millikan	*Sub-Electrons*
The charge does not depend on the radius.	The charge diminishes with the radius.
The charges calculated according to the Brownian Movement do not differ from those calculated according to the Stokes-Cunningham formula.	The two methods lead to absolutely different results.
Average mass and density are variable.	Average mass and density are invariable.
The "mobility" (*i. e.* the inverse of the coefficient of resistance) of the particles increases if the radius diminishes.	The "mobility" of the particles decreases if the radius diminishes.

It is therefore certain that the form of these particles is not spherical and that their density is not that of the pure metal. All the conclusions, consequently drawn from the law of Stokes-Cúnningham are illusory.

III—EXPERIMENTS MADE WITH PARTICLES OF TIN AND OF CADMIUM

We have tried to discover whether there is in general any possibility of obtaining solid metallic particles of spherical form.[27] The pulverizing of a metal in the voltaic arc being unable to furnish the desired result, we had recourse to other modes of production. We have more especially studied the two following processes:

Either the mechanical pulverization of melted tin in an inert gas (nitrogen), or the condensation in hydrogen (more or less pure), of vapors of cadmium. Neither of these processes furnished truly satisfactory results. Nevertheless, if we pulverize tin in an atmosphere of absolutely pure nitrogen the chemical nature of the metal is not altered, and if we then take care to prevent as far as possible the sudden cooling of the melted body, we are able to obtain particles of tin which are *almost* spherical; but the process is successful only by chance. We have not been able to find a method enabling us to obtain with absolute certainty solid metallic spherules, and the major part of the corpuscles observed exhibit more or less considerable deformations.

We may inquire whether the particles of melted sulphur of M. Roux were indeed entirely spherical. The sudden cooling of pulverized particles seems always to provoke changes of form. This would permit us to entirely explain the manifestly too low value of e obtained by this savant. We cannot here discuss the multiple causes of error to which this delicate method of determining the charge of the electron is subject. The experiment is exposed to perturbations very difficult to avoid, even in utilizing pulverized liquids. Besides changes of average density of the drops due to dust we may mention the volatility of the majority of liquids, which Millikan has so happily sought to evade by employing oil, and the formation of gaseous layers of absorption on the surface of the drops, whose influence we will shortly discuss.

However, these causes of error can modify only the last decimals of the result, and to find true "sub-electrons" we must have recourse to the pulverization of melted metals, preferably in the voltaic arc, the modifications of structure being probably the more considerable the greater and the more sudden the change of temperature.

IV—THE BROWNIAN MOVEMENT IN GASES

The question of sub-electrons is still not completely resolved with what has been said about the unjustified application of the law of Stokes-Cunningham to particles pulverized in the voltaic arc. Ehrenhaft and his pupil, D. Konstantinowsky, have had to resort to another process for determining the elementary charge which appears to eliminate the thorny question of the structure of particles.

The coefficient of the resistance which the medium opposes to the movement of particles can be determined, independently of the law of Stokes-Cunningham, by the observation of the Brownian Movement of particles. The inverse of the coefficient of resistance is called the "mobility."

This presents the signification of the speed which the particle acquires under the influence of a force equal to the unit. But the mean square of the Brownian displacements effected in a second by any particle is proportional to the mobility of the particle; the coefficient of proportionality, which depends only on universal constants and on temperature results from the theory of Einstein.

This method was employed for the first time by E. Weiss,[28] then by H. Fletcher;[29] finally Ehrenhaft and Konstantinowsky utilized it to give irrefutable proof of the existence of sub-electrons. The method differs slightly from that employed by M. Perrin to determine the number of Avogadro.

In place of observing the Brownian displacement of a suspended particle, one determines the fluctuations of the speed of the movement of the particle. Ehrenhaft and Konstantinowsky studied indifferently the rising or falling movement of the charged body; but A. Targouski[30] has proved that the variations of durations of the ascension are subject to very serious electric disturbances. It is necessary therefore to avoid taking them into consideration and to confine ourselves to the fluctuations *which we observe apart from all action of the electric field.*

Even in the view of Konstantinowsky the study of the Brownian Movement does not furnish very exact indications as to the existence of the sub-electrons. If one obtained in this way results which confirmed those deduced from the law of Stokes-Cunningham, one might essay to draw conclusions from it; but in reality one finds results absolutely contradictory for particles pulverized in the voltaic arc. The mobility, instead of augmenting for the smallest particles, diminishes more and more.

This result is paradoxical only in appearance, and is explained by the fact that the smallest particles are those whose structure has undergone the greatest modifications; but for Ehrenhaft and his pupils, who claim that their particles are spherical and of a known density, this fact proves that the theory of Einstein of the Brownian Movement is inexact.

It is useless to return to this question, sufficiently elucidated by what has just been said; we will, therefore, occupy ourselves exclusively with the results extracted from the study of the Brownian fluctuations of durations of fall.

In studying the ensemble of the numerical results obtained by this method with metallic particles, Targouski[31] has proved that one thus finds for the elementary charge figures lower by 30 to 40 per cent than the number obtained by Millikan, and he has remarked, moreover, *that the value of the elementary charge becomes more exact in the same degree that the ratio between the mean path of the molecules of the gas and the dimensions of the particle is larger.*

This might lead us to regard Einstein's theory as defective, but it might equally well be claimed that the theoretic laws are exact, and the method of observation on the contrary, subject to causes of error. These causes of error ought to present a statistical character and they ought to lose their relative importance when the Brownian Movement of the studied particle is sufficiently intense.

[TO BE CONTINUED]

[27] A. Schidlof and A. Targouski, C. R., Vol. CLXII, p. 788; May 22, 1916.

[28] E. Weiss. Wien. Ber., II a, July 1911, Vol. CXX, p. 1021.

[29] H. Fletcher, l. c.

[30] A. Targouski, Arch. d. Sc. phys. et nat., l. c.

[31] A. Targouski, C. R., Dec. 20, 1915, Vol. CLXI, p. 778.

Paper Films for Photographic Negatives*

By Ernest Constet

FROM the earliest days of photography attempts have been made to take pictures on paper rendered more or less transparent by wax or some other fatty or resinous material. Glass has generally prevailed because of its more perfect degree of transparency, but this quality is more than balanced by grave faults: its weight is a burden, not only to the tourist, but to the professional, whose archives soon become singularly heavy and cumbrous, while its fragility makes uncertain the preservation of documents whose value increases with age. Added to these inconveniences at present is its higher price, which adds to the cost of plates already become dearer by reason of the advance in bromides and silver salts. Celluloid is sufficiently light and transparent and resists shocks well, but is highly inflammable; contact with emulsion alters it rather rapidly, and it also undergoes changes of itself; its non-inflammable substitutes are still more readily altered, so that the preservation of "photographic minutes" is perhaps more precarious even than with glass.

What is apparently a preferable solution of the problem consists in pouring the emulsion over paper or cardboard, so preparing the support that the gelatine film can easily be separated from it after the operations of developing and fixing.

This is an old idea. It was tried in the days of collodion. In 1863 Alexander Arnstein made use of gelatinized paper over which he poured the solution of nitrocellulose. As soon as the negative was obtained he reinforced the collodion film with a gelatine layer to make it thicker, then after drying he detached it from the paper[1] support.

The same method was applied to gelatino-bromide from its first use. Milsom spread the emulsion upon paper, first gelatinized and then rubbed with white wax. The interposition of the fatty substance permitted the easy detachment of the film, and the negatives thus gotten were preserved in blank books of blotting paper.[2] In 1885 M. de Chenevières suggested several processes for preparing film papers, the most popular being to rub a gelatinized paper with talcum, and pour over the talcated surface first a layer of collodion and then a gelatino-bromide emulsion.[3] The Thibéaut cards and the flexible Balagny plates were prepared by similar methods. The Marandy films were based upon this principle, that gelatine spread over a surface covered with varnish having a resinous base does not adhere to it close unless there is added to it some substance, such as glycerine, for instance, which lends it a degree of plasticity. This substance being eliminated by the washing of the plate, the gelatine when dry is easily detached from the varnished paper.

Film papers offer certain definite advantages; they weigh far less than glass and permit the use of much thinner and lighter holders; they are neither fragile nor liable to change, the surface in contact with the sensitive layer entirely overcomes the halo and consequently facilitates the reproduction of subjects by artificial light without employing a special anti-halo coating. For an equal degree of sensitiveness the subjacent paper permits a shorter exposure than transparent supports, as M. R. Colson[4] has demonstrated, because the light which has traversed the emulsion is reflected from the white surface and returns to make an impression upon the silver bromide. The detached film is sufficiently solid, though extremely thin (thousands may be preserved in files which are not very bulky,) and this thinness permits printing from either side of the negative, an appreciable advantage either in the carbon process, where it enables one to get a positive proof in its true position by simple transfer, or in photomechanical processes, which require reversed negatives.

In spite of these qualities film papers were neglected when celluloid films appeared. The latter still enjoy a very legitimate vogue, which should not blind us, however, to their actual faults, high price danger of fire, and difficulty of preservation. These inconveniences and the present cost of glass justify a return to film paper. That now prepared by a French company offers a notable superiority of manufacture over those heretofore made: solidity of the film, great sensitiveness, convenience of treatment, greatly reduced weight and volume (one hundredth that of glass). The price is much lower than that of celluloid plates and films.

To use paper film in an ordinary holder it is necessary to slide each leaf into a carrier of thin tin. This is very simple, and of moderate price. In the plate carriers of magazines all that is necessary is to compensate the thickness of the glass by a piece of cardboard.

The development is controlled by watching the image by reflected light at the bottom of the tray as in the case of a photocopy on bromide paper, with this difference, that it is necessary to carry it farther, until the details seem to disappear and the whites begin to grow grayish. It is there rinsed for an instant in clear water and fixed in a simple solution of 20 per cent hyposulphite of soda without the addition of bisulphite or of acid. The sheet is left in the fixing bath at least ten minutes, to be sure it is well fixed, for we have not here the means of control afforded by transparent supports, where complete fixing is recognized by the disappearance of the milky aspect on the reverse of the plate. Immediately afterward the sheet is immersed in a 6 per cent solution of formol, where it stays five minutes. Afterwards it is washed for at least half an hour in running water or in a tray which is emptied every five minutes, then allowed to dry naturally, *i.e.*, without accelerating the desiccation by alcohol. As soon as dry the stripping may be proceeded with, but it is perferable to varnish the film before separating it from its support. A varnish which dries in a few minutes may be used. The film is first lifted by its corners with the fingernail or the point of a pen-knife; then a paper-knife or similar instrument is passed along the edges of the sheet between the film and the paper and the separation completed either by pressing the implement more and more towards the center or by exerting a steady pull upon the film, holding one of its angles in the right hand while the left hand keeps the paper flat on the table. The reverse side can then be varnished, so that both sides are protected. Retouching is done as in ordinary negatives.

*Reprinted fron *La Nature* (Paris).

[1] Bul. de la Soc. fr. de Photog., 1863, p. 112.

[2] Oda jir. The Gelatino-bromide process, 1877.

[3] Bul. de la Soc. Fr. de Photog., 1885, pp. 104, 119, 150.

[4] *Ibid.*, 1897, p. 109.

Strength of Zinc-Bronze Alloys

ONE of the conclusions arrived at in Technological Paper No. 59 of the Bureau of Standards on Standard Test Specimens of Zinc-Bronze is that the presence of oxides is one of the most potent sources of weakness in these alloys in their cast condition.

Rattan of Commerce

Varieties, Sources and Uses of an Important Tropical Plant

By C. D. Mell

RATTANS constitute a class of tropical products which rank very high commercially, and although willow, splint wood and the culms of various species of grasses have, in a large measure, taken the place of rattan products, there are still enormous quantities being imported for use in making furniture and numerous other articles. In fact, the use of rattan in this country has increased remarkably during the last two decades. What was at one time an insignificant industry in the tropical East has since developed into enormous proportions. It has recently been discovered that merchantable rattans occur also in the Philippine Islands, and while these are at present only a small factor in the world's commerce, it is believed that the United States will soon draw a large part of its requirements from this source. There are several species of climbing vines growing in southern Brazil and northern Argentina which have been found suitable for use in place of the East Indian varieties. The rattan substitutes are at present of comparatively little commercial importance outside of the region of their production. The true rattans of the East are frequently the subject of inquiries and, as the information published regarding them is somewhat scanty, it may be useful to record briefly a few of the more important facts relative to the plants producing them and the methods of obtaining them and their uses.

The *Bulletin* of the Imperial Institute of December 31st, 1903, states that the rattan canes, one of the most important products of the Malay Peninsula, are the stems of climbing palms belonging to several genera of the palm family (*Palmaceae*), some of the best known canes or rattans being those of *Calamus, Daemonorops, Korthalsia* and *Plectocomia*. Of these the *Calamus* constitute the most important group. Although genuine palms, yet from their slender stems, and their general habit, they have more the appearance of a tall grass. In their structural characters rattan stems bear very close relationship to ordinary palms, yet the rattan plants have been considered as one of the links in the chain of organization which connects the grasses with the palms. A few species form low bushes or small trees, but the majority of them grow in tufts of very long, slender, cylindrical and jointed stems or canes which are noted for being exceedingly tough, strong and durable. They vary from the size of a goose quill to more than 3 inches in diameter, depending upon the species and the age of the plant. Their slender stems rise among the loftiest trees of the tropical forests, over which they climb, giving the appearance of cordage stretched from tree to tree, supporting themselves by means of hooked or recurved spines attached to the under surface of the leaf stalks and the mid-veins. In the regions where they grow most abundantly, rattans often render the forests almost inaccessible by reason of their long and tough stems. The English-speaking people in Borneo and parts of India frequently call these plants "wait-a-bit," for the reason that they continually interfere with the progress of the traveler in the forest.

Early writers on rattan frequently exaggerated the length of these rattan stems. It was formerly supposed that the stems attained a length of from 400 to 600 feet, but the most reliable authorities state that the longest ones are only from 180 to 220 feet. The species in the hottest parts of the East Indies where they grow to best advantage have been described as growing to great length. The stems of *Calamus verus* are said to attain a height of 100 feet, that of *C. oblongus* 300 to 400 feet, of *C. rudentum* upward to 500 feet and of *C. extensus* as much as 600 feet. Rumphius states that one species attains the extraordinary length of 1,200 feet. As a matter of fact the largest and most resistent canes are produced in the old and dense jungles in deep situations by a species known as the cable cane (*Calamus rudentum* Lour.), which is said to grow seldom over 200 feet in length, while another closely related species (*Calamus pisicarpus* Blume) produces much smaller stems of only about twenty feet in length. The different kinds of rattans vary much both in size and in appearance. The smaller kinds are usually called rattans and bear this name in commerce, while the larger ones are known as Malacca canes in the trade. The smaller varieties usually come from Borneo and are esteemed finer than those produced in any other part of the world. The Malacca canes come usually from points in India and along the Strait of Malacca.

The smooth and shining outer portion of commercial rattan stems is remarkably flinty, owing to the deposit of silica in the epidermis. When this covering, which is tawny yellow or brownish on the surface and often delicately striate, is separated into strips it is commercially called cane and is used universally for caning the bottoms of chairs, of couches, and of other articles of furniture. This silicious covering gives the canes

Scene in a tropical forest where rattan abounds

extraordinary hardness, and the natives of the East Indies occasionally take advantage of this quality and use the stems for striking fire. Just beneath the lustrous outer layer is the strong inner fibrous tissue (core), which is dull gray or reddish white and is

Transverse section of rattan cane (*Calamus Rotang*) magnified 60 diameters

known in the trade as "reed." In consequence of its straight fibrous character the peeled canes are very easily split by special machinery into thin strips of great tensile strength and elasticity. These properties give rattan its value for use in braided work.

Rattan was originally brought from India, Java and Borneo into England and Holland as ship ballast, but it forms now a very important and valuable cargo from other Asian countries. A large quantity also comes from the Congo region in Africa, where the material is said to be practically inexhaustible. Owing to the difficulties of transportation and insufficient labor, the supply from this source is not likely to increase very materially for some time to come. The bulk of the raw material is furnished by Borneo, India, Ceylon, the Archipelago, and Malay Peninsula, which reaches the large markets in Europe and America through the ports of Singapore, Sarawak, Batavia, Penang, Calcutta and from parts of China. Before the war most of the reed used in this country was brought from the East to the port of Hamburg, Germany, where it was manufactured into cane and rattan core. Similarly enormous quantities of rattan core or china reed and cane were obtained from China. Since the German markets are closed the bulk of the core for the American markets is derived from Chinese sources, where the material is sorted on the American gage size; the most common sizes are Nos. 4, 4½, 5, 5½, 6, 6½ and 7.

The bulk of the manufactured rattan brought into this country at present comes from Singapore, and is shipped direct to Wakefield, Mass., where it is split, cut and prepared for use for the leading manufacturers in Gardner, New York, Chicago, and other places in the United States. Here careful sorting is done, which is a labor requiring special knowledge and training; washing is done by means of a complicated but carefully prepared process; trimming consists in equalizing rough and uneven joints; bleaching is a very necessary process and is done by means of chemicals. The sorting of colors, sizes and kinds is work which requires long study and experience. Machines are used in the factories for splitting the rattan, which is destined to be used for caning chairs and like usage. Machines are also patented which convert the pith into a thread-like substance, employed in fine basket weaving, and also into strips, imitating perfectly whalebone, which is sold in large quantities for umbrella ribs and for use in the manufacture of corsets. When the rattan industry was first organized practically all this inner substance, which is now so highly esteemed for weaving, was burned up. To-day this yields from 8 to 20 cents per pound, and is extensively employed in the manufacture of carpets, mats and mattresses, and in Europe for withes for farm use.

The wholesale price of rattans is now nearly three times greater than in the beginning of 1914. Even long before the war the value of rattan was gradually going up so that it was much more expensive than the best grades of imported willow rods. The chief cause of this increased value was based on the fact that the native rattan gatherers on the Malayan Peninsula, in Sumatra and Borneo, where the largest supplies were obtained, had to keep step with the greatly increased demands of the market. They were obliged to penetrate deeper into the jungle to seek new fields and to go much further from home to cut it. In view of distance and natural obstacles they could carry less at a time than was formerly the case. This increase in the price of rattan stimulated a greater and freer use of basket willow and other elastic woods in the manufacture of basket work in this country and abroad. Rattan will not become much cheaper after the war because the demand for it will be greater than the supply. The value of rattan imported annually into the United States is approximately $1,000,000.

In the countries where rattan abounds, the inhabitants make use of it for a great variety of purposes, baskets of all kinds, mats, hats and other useful articles being commonly made of it. It is either used locally or exported for such purposes as basket making, furniture, cordage, walking sticks, fishing rods, as a substitute for punkha ropes, etc. The split rattan is extensively employed in this country for the bottoms of chairs, couches, sides of carriages and similar purposes. Their most important use in the Orient, however, is for the manufacture of the ropes and cables usually employed by coastwise vessels. In the Himalayas they are used in the formation of suspension bridges across rivers. Certain varieties are used chiefly by the natives of India for weaving into wicker work of various

A portion of a rattan stem of *Calamus Diepenhortii* with leaf base removed, showing internodes; also part of leaf and fruiting stalk with fruit

sorts of basket work are made of split cane. Very expensive cabinets with drawers are frequently made entirely of rattan. Its native applications are about as numerous as those of bamboo in China and Japan. The natives of Andaman even make knives of pieces of the stems of certain species cut in such a manner as to form a sharp edge.

In the United States rattan is used with advantage in making baskets for fruit dealers, gardeners, florists, hucksters, potters and grocers. It is used also for coal and clothes baskets, cars for balloons, rustic and garden chairs, lattice work, rough door mats and for brooms. Rattan is employed also for making whips ,and at one time was so highly esteemed for this purpose that one pound of rattan sold for about 70 cents, while whalebone, which was used for the same purpose, brought only 25 cents per pound. Rattan is also used extensively for making baskets for protecting sulphuric acid bottles. It has a large amount of silica on the outer surface and the acid does not affect it. The willow which was formerly used was a continual source of annoyance, because when the acid spilled upon the willow it soon rotted and the carboys often broke. Short-jointed, black-ringed rattan sticks, which are especially pliable and elastic, are also used for making walking sticks under the name of sugar cane. Brown strips several centimeters long served as a substitute for piassava fiber, which is obtained from the leaf-stalks of *Attalea funifera* Mart. Slender sticks impregnated with caoutchouc are used as a substitute for whalebone in the frames of large umbrellas. The cane is used, according to its thickness, for entirely different articles, from walking sticks, whip and umbrella handles, to fine basket work—in fact, for anything where lightness, flexibility and durability are required, even to a cheap and light substitute for whalebone. But probably the most extensive use made of it is in the manufacture of light furniture, and, after it is split and woven, for the seats or backs of chairs. The strips from the outside, with the smooth outer surface, are employed for caning chairs, settees, wagon bodies, etc., while lusterless strips

A portion of a rattan stem of *Calamus Scipionum* with leaf base attached; it also shows leaflets and a pair of fruiting stalks

kinds. In Java the cane is cut into fine strips, which are platted into excellent mats or made into strong and at the same time very neat baskets. In Japan all

from the inside of the cane serve for making furniture, baby carriages, baskets, sieves, mats, ropes, covering for demijohns and various other useful articles.

The Production of Fluorescent and Phosphorescent Effects*

By F. Harrison Glew

In general illuminants operate by incandescence, *i.e.*, the production of light through high temperature. Other processes, not involving the action of heat, are termed luminescence, and are illustrated in a few illuminants, *e. g.*, the mercury vapor lamp and, to some extent, in flame arcs.

To illuminating engineers the processes involved in luminescence have therefore a direct interest, apart from the wider aspects of these phenomena.

One of the most familiar examples of such effects is the firefly, the luminous efficiency of which is believed to be far higher than that of any existing illuminant, and other insects and marine forms of life have similar properties. The production of light appears to be due to chemical action. The glow of phosphorus (from which the term "phosphorescence" is derived) in the dark is due to slow oxidation and luminosity may also be produced by the oxidation of pyrogallic acid and other organic materials. Such effects are termed "chemiluminescence."

"Tribo-luminescence" is the term applied to luminous effects produced by friction, *e. g.*, by rubbing or scratching certain crystals (quartz, sugar, fluorspar, etc.).

When the impact of visible light on a substance produces luminosity of a different (by "Stoke's Law" a lower order) color, this is termed "fluorescence." The effect is exhibited by fluorspar and similar crystals. When the effect still persists after the cessation of the stimulating action so that the luminosity persists in the dark, it is termed "phosphorescence." A good example of fluorescence is to be found in the transformation of violet and ultra-violet light into visible red rays by the rhodamine reflector, used with the mercury lamp to modify its spectrum. Fluorescence may be excited by other forms of radiation; for example, that emitted by an X-ray tube, or the spark from an induction coil.

Luminous paints which, after exposure to daylight, retain luminosity for some time in the dark, have been known for many years. Crystals of calcium sulphide phosphoresce blue, zinc sulfide green; other materials give a less luminous effect in yellow, red and other colors. The manufacture of such substances and ingredients used to accentuate their action is a complex process, as qualities quite apart from chemical purity are required.

*An introduction to a discussion before the Illuminating Engineering Society (England) and published in *The Illuminating Engineer*.

For example, the form of zinc sulphide, giving the best luminous effect on exposure to daylight, may not be that most suitable for treatment to produce continuous fluorescence.

The luminous effect induced by light in these substances is transient, diminishing greatly after a few hours in darkness. At the moment immediately after strong excitation a brightness possibly exceeding one foot-candle may be shown to exist. But in a fraction of a second this initial strong effect vanishes, and although thereafter the diminution is more gradual, a brightness below that of a white surface illuminated by moonlight is soon reached, and half an hour afterwards the luminosity is very much less still. Experimental data on the degree of luminosity attainable by strong excitation by sources rich in ultra-violet rays are needed, but the measurements involves great difficulties.

Such phosphorescent substances have found various special applications. The strongest effect is produced with the substance in a powder, but, mixed with dilute varnish, it can be applied in the form of paint.

The most important practical results have so far been obtained with the self-luminous paints, which consist of zinc sulfide with a small admixture of radio-active constituents. Radium gives off three forms of rays—alpha, beta and gamma—the former of which is responsible for the chief excitation of luminosity. Radium itself wastes away at a rate which will reduce it to half quantity in 1,000 years. This alone, therefore, would cause an inappreciable deterioration in luminous effect. In fact, however, self-luminous paints decay at a rate varying according to their radium constituent. A diminution of 50 per cent in brightness in the course of a year is not unusual, but much greater dimunitions with a larger percentage of radium have been recorded. Half value in about twenty-four hours occurs with 74 mgrm. radium bromide per gramme of zinc sulfide, which strength I find to be equivalent to the light of the glow-worm. On the other hand, the actual brightness, within limits, is roughly proportional to the radium content. It is therefore of very great importance to determine the order of brightness necessary for certain purposes, and not to exceed this required value, since any addition beyond this point adds to the expense and diminishes the life of the material. Up to the present time no satisfactory means or regenerating these materials has been found, although this is possible with some substances. The diminution in brightness, as stated above, cannot be attributed to decay of the radium component and is believed to be due mainly to deterioration of the zinc sulfide during bombardment. In cases in which the powder is enclosed in glass, the transparency of this may also be affected by the radium in course of time, and the same applies to the varnish used as a binding material when the compound is applied in the form of luminous paint.

It is to be noted that the mixture with varnish is equivalent to dilution of the radium element; speaking generally, the brightness of material of given composition used as varnish will be about one-quarter of the value when used in the form of powder.

Such materials have many important applications in connection with the war, and the whole subject offers an opportunity for profitable research, and deserves to be more closely studied.

A New Passenger Ropeway

The methods of constructing ropeways have been so thoroughly perfected that large numbers have been built for the conveyance of both passengers and merchandise in various parts of the world, and have proved entirely successful and satisfactory. A new instalment that has recently been put into operation at Bozen, in Germany is thus described. The way is 5,400 feet long, with a rise of 2,750 feet, the grade being an average inclination of 43 degrees. The up and down lines are located 20 feet apart and each consists of two steel cables, 20 inches apart, on which runs a four-wheel trolley. The cars, of which there are two, each with a capacity of sixteen people, half inside and half outside, are attached to these trolleys, and the two cars are connected by double cables, operated by an electric motor located at the highest sattion. The current is derived from a central station, but there are batteries for use in an emergency, and hand gear is also fitted to the cars, one of which descends as the other ascends. This ropeway is supported on steel towers, the highest one being 53 feet, while the longest span between towers is 1,300 feet.

Producing High Vacua

When a very high vacuum is desired finely divided copper, such as is obtained by reducing a solution of a copper salt, and commercially know as "precipitated copper," may be used with advantage to absorb the last traces of gases, which it takes up rapidly. When used for this purpose a few grammes of the copper are placed in a bulb which is sealed to the vessel to be exhausted, and while the copper is heated to about 250°, to free it of any gases it may be holding an air pump is operated to effect a partial vacuum. The pump is then disconnected, and as the copper cools it rapidly absorbs the remaining gases. This absorption is not a chemical action, as the gases are again liberated when the copper is heated.

Waste in Coal Production*

A Discussion of Conditions Existing in England

By Henry Louis

At a time when the subject of fuel economy is being brought so prominently before our notice, it is important to have before our eyes a complete review of each and every operation connected with coal in which waste occurs, and in which therefore the introduction of more economical methods is at any rate possible. The waste and losses connected directly with the getting of coal are by no means the least of the various forms of loss, and I propose in the present paper to lay before you a brief account of some of the prinicipal forms in which such waste occurs. A clear conception of the nature of such losses is obviously the first step towards their avoidance.

The coal output for 1913 is given by the Home Office as nearly 287½ millions of tons, and it is important to note in the first instance how much of this total output is actually available for use by the nation at large, and in the second place how much other coal has been sacrificed in order to obtain this output. Put in somewhat different words, the first named portion of the investigation refers essentially to the saving that could be effected above ground in dealing with the coal after it had been brought to bank, and the latter to the saving that might be effected in the underground operations of the colliery.

From the total output of coal there is first of all to be deducted the coal used in what is generally spoken of as colliery consumption. Obviously a certain proportion of the coal raised in the country is consumed in raising it; in some districts, some or all of the colliers are supplied with free coal, which is sometimes included under the head of colliery consumption. This is, however, not a correct way of looking at the matter, because the coal thus supplied to the men should be looked upon as being a portion of their wages paid in kind instead of in cash, and hence this coal is sold or given in place of money, and should not be included in colliery consumption properly so-called. The only objection to the practice of giving free coal, at any rate from the standpoint of the present discussion, is that such coal is apt to be, and as a rule is used very wastefully, and that if the men had to buy the coal and pay for it, more economy would be observed, and a considerably smaller quantity of coal be made to answer the purpose.

Colliery consumption properly speaking should be restricted to mean the coal used in generating the power necessary to work the colliery. It would not be difficult to arrive at the amount thus consumed; all well managed collieries keep a careful record of their own consumption, and in some districts attempts have been made to obtain approximate statistics for the entire district. It would, however, need a proper inquiry backed by due authority to obtain figures for the country as a whole, because it is precisely those collieries where the consumption is greatest that will be the least willing to supply such figures. A certain amount of difficulty may arise from the fact that the coal thus used is of inferior quality, and not infrequently unsalable. Within late years efforts to use inferior coal have been multiplied, and in many cases have been attended with marked success; I know cases where the whole of the power required to work a colliery is now being obtained from material which a few years ago was thrown on to the waste tip, and the use of inferior coal in gas producers is contributing to the extended employment of such material. There is still, however, too great a tendency among colliery managers to consider that if power is generated from an unsalable material, there is but little need to exercise economy in its consumption. Such a view is one that should not be allowed to obtain, and it has only arisen owing to the fact that the calorific value of the fuel consumed is too often disregarded and its money value alone is taken into account. It naturally happens that many collieries are so situated that they necessarily produce a certain amount of impure and dirty coal, the money value of which is less than the cost of marketing it, and the assumption is often made that such coal is therefore worthless; that it has, however, a very definite value as a fuel is shown only too conclusively and too unpleasantly by the burning pit heaps that may be seen in any colliery district. Definite information as to the quantity of coal burnt for colliery consumption is not obtainable, and a very rough guess is all that is possible at present. From my own observations I am inclined to think that the colliery consumption of the country is somewhat of the order of 7 per cent of the output, or say about twenty millions of tons. It is evident that if groups of collieries would combine to erect central gas producer plants, using low-grade coals, from which power could be distributed to the various pits within a reasonable radius, the saving that could be effected both by the utilization of the by-products and by the substitution of inferior for better-class coal in the generation of power, would amount to a very large annual sum.

In many districts vast quantities of fine coal dust accumulate in the screening plants and lie there until periodically, when the nuisance becomes too great, they are cleaned out and the dust thrown away. I have been in colliery heapsteads in South Wales where the dust was literally ankle deep. Such coal dust is in many cases quite fine enough to be used direct for firing boilers or furnaces, and is well adapted for this purpose; it could be readily and cheaply cleaned and graded by the use of some form of pneumatic dressing machinery, such as has been erected in several of the Westphalian Collieries. Nothing of the kind has been attempted, so far as I know, in this country, and this valuable article continues to be thrown away. Here again is a source of economy which in some parts of the country would be decidedly important.

Turning next to the underground operations, the waste of coal in the pit may be considered under two heads, namely more or less accidental and more or less deliberate. It is practically impossible to win the whole of the coal in any seam; some is always lost, owing to the waste in undercutting, the crushing of ends and of odd portions of pillars, and the leaving of barriers and shaft pillars. The intention is always that a shaft pillar shall be robbed when the rest of the pit has been worked out, but it frequently happens that by the time that the latter occurs, much of the coal in the shaft pillar is so crushed that it cannot be won. As regards barriers they are in part left deliberately, while in other cases the intention is ultimately to win them as far as possible, though here again this cannot always be accomplished. The waste in undercutting is being gradually decreased by the use of coal-cutting machines instead of undercutting by hand, owing to the fact that the machine makes a much narrower cut than is possible with the pick, and is often able to undercut in clay, where the hewer would have to cut in coal. More might no doubt be done in the substitution of machines for hand-labor, but the subject is a difficult and a complex one, and I do not intend to suggest that the indiscriminate use of coal-cutting machines is in all cases to be recommended. Nevertheless it ought not to be forgotten that our coal reserves are a national asset, and that the interests of the nation at large should receive some consideration as well as the immediate profit that the colliery owners draw from their operations.

The crushing and loss of some portions of the seam are almost inevitable on any system of working; such loss is no doubt less when the coal is worked by longwall than by bord-and-pillar, but here again the best system of working any given seam does not depend upon this consideration alone, though I would urge that the national aspect is too often entirely neglected. Upon the whole there is no doubt that the use of the longwall method is extending, and that loss in working is decidedly less than it was, say 50 years ago, and there is every reason to hope that still further improvements in this respect may be looked for. Improved methods of stowage, such as the well known hydraulic methods, may also be helpful in this matter. An important fact to be borne in mind is that a colliery is after all not a philanthropic institution, and that no colliery manager is going to extract small remnants of coal pillars when the cost of doing so is greater than the cash value of the coal, and further that his costs depend largely upon the prices of pit timber, because the removal of such small portions of coal is rarely possible except by the lavish use of pit-props. That the price of these has risen lately to formidable figures is well known, the main reason being that for many years afforestation has been wholly neglected in this country. What little has been done has been due to the enterprise of a few individuals, and it is impossible to acquit of blame in this respect some semi-public bodies, such as the Ecclesiastical Commissioners, who hold vast areas of land. They prefer to get the maximum immediate revenue out of their lands, say by letting them as grouse moors, instead of contenting themselves with a lower immediate return, and planting timber, which would in the course of time not only yield for themselves a handsome income, but prove an important advantage to the industries of the nation. The need for cheap timber if the maximum output is to be obtained from a given area of coal may not at first sight be very obvious, but there is nevertheless a very close connection between them. As regards the leaving of barriers between adjoining properties, this has in the past been a very serious source of loss, and is still to-day, though it is to some extent, decreasing owing to the growing tendency of colliery companies to amalgamate, and for large companies to absorb smaller ones, so that ever larger areas are being controlled by one interest; even so there is room for much improvement, and possibly legislation on the subject might not be altogether out of place. I hold the view that although coal in this country belongs rightfully to individuals, it constitutes as a whole a national asset, and the nation is entitled to protect itself against undue waste. As to the proportion of coal that is left in the ground, here again nothing more than a very rough guess is possible. I estimate the proportion as something of the order of 5 per cent of the coal existing in the seams, so that the total quantity is formidable enough. It may be as well to point out that the coal thus left in the ground, cannot be, as has sometimes been asserted, looked upon as a reserve that future generations may be glad to utilize. On the contrary, coal thus left behind cannot be won afterwards, and must be looked upon as irretrievably lost to the country.

A source of loss that may properly be referred to at this point is that due to "gob-fires," that is fires underground originating in the spontaneous ignition of small coal left behind in the worked-out portions or goaf of the coal seams; such fires often spread to the coal seam proper, and large areas of coal have thus at times been lost. The question of the best means of preventing such gob-fires is now attracting much attention, and excellent work upon it has been done within the last few years in the Research Laboratory of the Doncaster Coal-Owners. It has been attacked mainly from the standpoint of the chemist, the object being in the first instance to find out what are the causes and conditions that favor the spontaneous ignition of coal, and in this way to arrive at the proper remedy to be applied. There are good grounds for saying that the theory of the subject is beginning to be well understood, and that the colliery manager ought, in the light of the scientific information thus given, to be able to keep losses of coal due to gob-fires within very narrow limits in the near future.

In addition to coal thus accidentlly left behind in the pit, there are many cases in which coal is deliberately left behind or thrown back into the goaf.

In many parts of the country where non-coking coal is produced all small coal is left underground on the plea that it would cost more to bring it out than it would fetch in the market. This coal is not mere dust, for in many cases nut coal is sacrificed in this way; in parts of Nottinghamshire I have seen coal loaded underground with a fork with 1½ inch tines, all coal under 1½ inch being thus thrown away. It need hardly be said that this coal was quite as good from the point of view of heat production as the coal that was sent up the shaft and much of it could have been used at once for firing boilers. How much coal is lost in this way it is difficult to say, but these are cases where the coal thus wasted amounts to over 20 per cent of the output. The same is also true of many parts of South Wales.

Again there are many cases where only the better portions of the seams are being won, the rest of the coal being left behind and lost, simply because it is of somewhat inferior quality, though it is a matter of fact quite capable of being utilized. Take for example a statement from the Mines Report of 1910, referring to the Barnsley Seam, worked at a number of mines in the Doncaster district: "at several of these mines nearly one-half of this fine seam is left unworked, the 'top-softs,' about four feet thick, being left to fall in the goaf. This part of the seam is not of such high quality as the better portion, and that is the chief reason for it being left unworked. . . . To lose practically 40 per cent of this seam is also a national loss." A number of analyses of the Barnsley Hard and of the Barnsley Softs from the Doncaster district have recently been published in some of the papers issued by the Doncaster Coal-Owners Laboratory, and these show practically no difference in chemical composition. It is quite certain that as re-

*From the *Journal of the Society of Chemical Industry*.

gards calorific value there cannot be any serious difference between the two classes of coal.

In the Barnsley district proper, a certain thickness of the seam, sometimes amounting here to more than 40 per cent of the whole, the "Top-Softs" and the "Bags" as the upper portion is locally called, is very generally left behind in the goaf. Apart from its softness, it is a good coal; a sample recently tested in my laboratory gave a calorific power of 13,400 b.t.u. and 3.8 per cent of ash.

In Fifeshire the Great Seam 6 feet to 8 feet thick consists of about 2 feet of Ironstone, about as much common coal, and then about 3 feet of Cannel or Parrot coal. The latter alone is worked, all the rest of this fine seam being left behind in the goaf.

In Lanarkshire the Ell Coal, about 6 feet in thickness, is worked, and the Head Coal, about 2 feet in thickness, left behind in the goaf.

These few examples, taken somewhat at random, will serve to exemplify the nature of the loss of coal that is here discussed; in most cases the coal thus left behind must be looked upon as totally lost; in others it may be in part recovered. Thus some of the areas in Lanarkshire above referred to are now being worked over again, with the object of recovering as much as possible of the Head Coal previously rejected but obvioulsy such an operation can never be a very satisfactory one. In many districts where there is one particularly good or especially valuable seam, this is often worked out before any other seams are touched, without regard to the fact that such working damages other seams less valuable to-day, but nevertheless containing coal of quite good quality. The result of this damage is that a certain proportion, or possibly in some cases the whole of these other seams is rendered unworkable, and great loss of coal is thus brought about.

It is practically impossible to present any figures showing the amount of coal lost to the nation as the result of this deliberate waste, but it certainly amounts to enormous quantities in the aggregate. It is not easy to suggest any remedy for this loss; some authorities favor legislation, and the imposition of heavy taxes upon coal left behind has been suggested. This can hardly be looked upon as a scientific solution of the problem, and undoubtedly a better remedy would be the invention or the elaboration of methods of utilizing these inferior coals, which would give them a value sufficient to make it worth the while of colliery proprietors to work the whole of their coal. Some of these difficulties are unquestionably connected with our systems of mineral ownership, under which two seams within the same area may be let to different people, each of whom works for his own interests alone regardless of the interests of the neighbor above or below him. The importance of the question is very great and it undoubtedly deserves the fullest possible investigation from every standpoint, there being probably no portion of the entire subject of coal economy that promises more valuable results.

I wish to state definitely that the all important question of safety is in no wise involved in the considerations here submitted, or rather that the reform of most of the sources of waste that I have indicated must result in increased safety for the coal miner. The diminution of gob-fires is obviously a case in point. Again, if it were possible to turn to good account the accumulations of fine coal dust, which constitutes such a grave danger in most of our collieries owing to the disastrous explosions to which it may give rise, the removal of this dust from the workings might readily become a source of profit instead of a loss as at present. It need hardly be said that such coal dust could, as has already been pointed out, be employed directly for firing, and that its cleaning and subsequent utilization should present no unsolvable difficulties. The coal left behind in the goaf is naturally also a source of danger to the coal miner, and in this way again the successful utilization of inferior coal would contribute to the safety of our collieries. The subject of safety is one of such supreme importance, that I have thought it advisable to refer specially to the fact that decrease in the present waste of coal would mean, if anything, a corresponding diminution of the risks to which the coal miner is exposed.

Zuni Chronology*

By Leslie Spier, American Museum of Natural History, New York

In connection with ethnological studies in the southwestern United States, the American Museum of Natural History is conducting an archæological survey of the same area. This provides the necessary background for a complete understanding of the ethnography of the region. While much energy has been expended in the Southwest, chiefly on the description of cultures, little progress has been made in the delineation of its culture-history through want of a chronology for the region.

The problem takes definite form when related to the ethnologic study of the social structure of the Zuñi tribe now being made by Prof. A. L. Kroeber of the University of California. It is conceivable, for instance, that a far-reaching effect may have resulted from the concentration of the Zuñis into a single huge community from their several villages of early historic times (the famous "Seven Cities of Cibola"). What can archæological method tell us of the former groupings of these people, of their ultimate origin and their relations with other peoples? The answer to the problem rests on the establishment of a chronology which will order the confused mass of cultural data into a culture-history.

The possibility of attacking the problem in the vicinty of Zuñi itself was made clear by the richness of the finds of the Hemenway expedition of 1888 under Cushing, Bandelier and Hodge, by a later hasty reconnaissance of the region by Fewkes in 1890,[1] and finally by Kroeber in a suggestive study incidental to his ethnologic work in 1915 which indicated the main direction the chronology would take.[2] The present study was undertaken by the writer in the summer of 1916.

The pueblos of the Zuñi tribe occupy a strategic position for the study of the Southwest. They lie on the headwaters of the Little Colorado River in central western New Mexico, occupying a central location in the area. The two great areas of ruined pueblos lie one along the northern margin of the Southwest culture province in the drainage of the San Juan, the other along its southern margin in the Gila and Salt River watersheds. To the east, the occupied villages of the Pueblo Indians stretch along the Rio Grande, and from that center an extension of the modern culture including Zuñi stretches westward into northern Arizona. We now have Nelson's partial chronology of the Tano tribe[3] and Kidder's suggested sequences for the Pajarito plateau[4] and for Pecos pueblo,[5] all on the Rio Grande. A chronology from the western section of the pueblo area is therefore a desideratum.

The procedure involved in this task presents some novel aspects. Simultaneously in 1915, N. C. Nelson, A. L. Kroeber and A. V. Kidder arrived by three different inductive methods at the same conclusion, viz., that the characteristic Southwestern pottery was of the highest evidential value for the purpose of reconstructing the sequence of pueblo occupation, or, in the widest sense of the term, establishing a chronology. Their methods of reconstruction were respectively stratigraphic observation of refuse deposits, the hypothetical ranking of surface finds and the observation of concurrent variations, and the hypothetical seriation of the several pottery techniques. Of these three methods, the advantages rest with the first, but its application in the case of Zuñi finds was precluded by the shallowness of the refuse deposits at most of those ruins. The writer was therefore led to combine the two methods of stratigraphic observations and hypothetical ranking of surface finds.

Where stratigraphic observations could be made it was observed that the variable value of one fluctuating pottery type, "corrugated" ware (so named for its characteristic plastic decoration), could serve as an index of stylistic variations in the whole pottery art. On analyzing for their type content the samples of potsherds collected from the surface of ruins for 50 miles up the Zuñi valley and from their refuse deposits, it was found that the resulting data fell into two groups. In both groups corrugated ware was present in the samples in amounts varying from 2 per cent to 60 per cent, but in each group the accompanying wares differed in type or in proportions, or both. For instance, samples of sherds collected from two ruins showed corrugated ware present in each to the extent of 40 per cent of the whole pottery art, but associated with this at one ruin was 60 per cent of a white ware, while at the other 23 per cent of red ware and but 37 per cent of white were found. For synthetizing these data we had at hand three premises: some of the ruins were claimed by the Zuñis as their former villages and others were so mentioned in historic records; the whole group of ruins stand somewhat isolated from other groups in the Southwest, and finally, the decorations on the pottery found in them had sufficient individuality to set off the whole group from the rest of the Southwestern ruins.

To synthetize these data we had two guides. It became clear while making stratigraphic observations at the historic ruins that while corrugated ware is represented to the extent of only 2 per cent in historic ruins and in modern Zuñi, it had played a larger rôle in the pottery art of earlier times. Similarly, the oldest remains in the valley showed an analogous variation in the use of corrugated ware, but in the opposite direction suggesting its coming predominence at a later period. Assuming then that we had here the end and the beginning of a stylistic pulse—an assumption made strongly presumptive by observed sequences in other sections of the Southwest—we ranked the data according to the ascending values for corrugated ware up to the maximum and then in descending order to the values for the recent villages. The validity of such procedure lies in the observed seriation of the accompanying wares: when a series of three or more distinct, but mutually dependent values are ranked according to some postulated sequence for one, and the other values are found to present serially concurrent variations, it may be safely concluded that the result is other than fortuitous. The results in this case amply justified the assumption. The fluctations in the ceramic art of the Zuñi thus stand revealed and are directly translatable in chronological terms.

The results obtained from the application of this chronology were the following:

1. The chronological scale itself shows a sequence of the pottery types, or rather of the predominating wares in the order of white, corrugated, red, black and with the last buff and white. Of these black is a dull unsliped ware, corrugated shows the familiar indented coils, and the decorated wares are black-on-white, black-on-red, black and white-on-red, brown-on-buff and brown and red-on-buff, and the modern varieties of white ware. The sequence of the techiques parallels Nelson's for the Tano ruins in its general outlines: two-color and later three-color painted ware, two-color glazed ware, three-color combination glazed and painted ware, and modern painted ware, with corrugated ware appearing at all times and black ware in later periods.

2. The Zuñi valley has been occupied continuously from an early period. The occupation has been transitory, no site being occupied for any considerable period. Certain major shifts of population are observable however: first to the northeast and east barely crossing the continental divide, later a return to the Zuñi basin still occupied by the Zuñis.

3. The Zuñis first occupied single houses and later communal dwellings of the well-known pueblo type. The former are uniformly small, the latter rectangular or circular structures of considerable extent. It is not clear that the first type developed into the communal dwelling. This sequence of architectural types has been often postulated by older writers, but never proved.

The problem has then found a partial solution, inasmuch as we have traced the growth of Zuñi communities and the ancient isolated character of their habitat. On the other hand the evidences for cultural isolation lie only in the development of such items as pottery designs of specifically Zuñian character, the general nature of their culture-history as a whole showing a common growth with their Rio Grande neighbors.

The few data now at hand for the Southwest suggest a marked uniformity of culture throughout that area from the earliest times, with the gradual individualization by the several tribes of certain minor culture traits.

Whatever its specific results, this study has shown that the method of assumed seriation can be applied to archæological phenomena. So far as the method is concerned, the novelty lies in its application to American culture-history.

The full data will be published in the *Anthropological Papers of the American Museum of Natural History*.

*A paper communicated to the National Academy of Sciences by H. F. Osborn, and republished from the Proceedings.

[1] Fewkes, J. W., *J. Amer. Ethn. Arch., Boston*, 1, 1891.

[2] Kroeber, A. L., *Anthrop. Papers Amer. Mus. Nat. Hist., New York*, 18, 1916; these Proceedings, 2, 1916, (42-45).

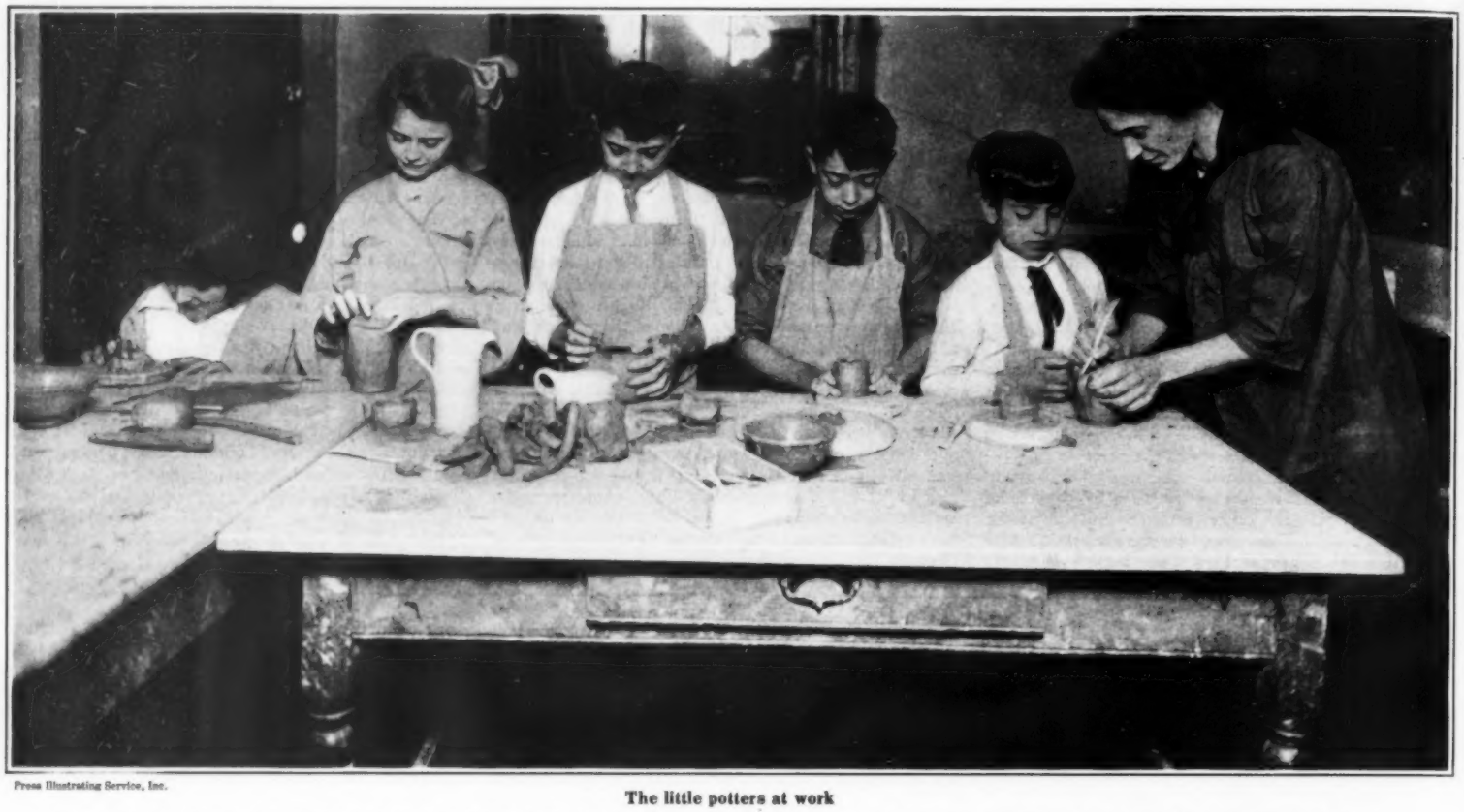
[3] Nelson, N. C., *Amer. Anthrop., N. S.*, 18, (159-180).

[4] Kidder, A. V., *Memoirs Amer. Anthrop. Assn.*, 2, (407-462).

[5] Kidder, A. V., Proceedings of the National Academy of Sciences 2, 1916, (119-123).

Modern Marine Dredges

Dredgers can now deal safely and expeditiously with very difficult material such as sandstone, shale, lignite, stiff blue clay, or hard chalk. The Panama Canal being in a constant state of requiring attention from dredgers owing to the frequent collapses of the sides and bottom upheavals, it is interesting to note the type adopted in the canal zone. They are of the dipper 15-cubic-yard variety. Their ability to dig into and to dispose quickly of any of the softer rocks, even at a depth of 50 feet, and to load into scows of almost any size, makes them very valuable tools for this class of work. They are capable of dredging 7,000 to 10,000 cubic yards of rock per day of twenty-four hours, the quantity dredged naturally depending upon the hardness of the material. Each dredger has two dippers respectively of 10 and 15 cubic yards capacity, the dipper handle being 72 feet long. The main hoisting engines are of the twin-tandem compound type, and the winding drum is graduated so as to give a low speed when digging. The swinging engine is of the double-cylinder high-pressure type, with steam-operated link reversing gear.



Press Illustrating Service, Inc.

The little potters at work

There is a joy in creating something, and again psychologists tell us that the way to guard against a boy's tendency to destroy things is to interest him in constructing things

Teaching Children To Be Useful

A SERIOUS problem in all large cities is what to do with the children during their waking hours when not in school. In the poorer districts, which furnish the greater portion of the children, the homes are small and crowded; there is nothing for the children to do there and they are in the way, so they are sent out into the streets to play and amuse themselves, and there they are liable to meet undesirable associates from whom they learn bad habits that seriously influence their future lives. To meet these conditions people who make a practical study of social welfare have established, in many of our larger cities, "Settlement Houses", where not only is amusement provided for the children during their hours of recreation, but practical instruction is given in many things that are useful. The system of these social workers has proved so beneficial that in many cities the public school authorities have adopted similar methods by giving various kinds of entertainments in the school buildings, fitting up the spacious roofs for recreation purposes and in other ways endeavoring to make the school house a social center for the pupils and their families. But after all a school is a school, and the children naturally seek a change from the scene of their daily work. This the Settlement House furnishes, especially as it provides for children of every age, even those too small to attend regular schools.

While the fundamental feature of a Settlement House is amusement, as through it a strong hold is secured and maintained on the children, the practical side of their work is the main purpose, and many useful things are taught; but the classes are so conducted as to make the work attractive. A most effective way of securing this result is to let the children work for themselves, that is to share what they produce with them; thus in the cooking classes, where simple processes that they can introduce into their homes with advantage are taught, the children eat the things they make; and in these classes few girls are so small that they cannot take some part. The sewing classes are particularly efficient in practical results, for the little girls are taught to cut and make their own dresses, which, when finished, belong to them, and an attractive dress of their own handiwork is always a thing to be proud of. There are other classes where carpentry, basket making and chair seating are taught, and many of the things made here can be sold, and the proceeds are shared among the workers, or they are allowed to keep articles that are useful in their homes. All of these methods infuse a personal interest into the work, and what they do in these classes takes on more the character of amusement than real work; moreover, they are acquiring knowledge and experience that can hardly fail to be of permanent benefit both to the children themselves and in their homes.

One class that is popular with all children, whether boys or girls, is that where clay modeling is taught, for every small child takes an instinctive delight in making "mud pies," although in this class the play is turned in useful directions. To most the class it is simply a matter of amusement, but most all are able to gain sufficient skill to produce simple crocks that can be sold, and this is a strong stimulus to serious efforts. Some of the little potters, however, develop exceptional skill and a perception of form and proportion, and these turn out very creditable dishes and jars that are readily disposed of. Occasionally real artistic talent is developed, and in one case in New York, a boy displayed such real genius that, as soon as he was old enough to leave school, he was given a chance in a real pottery works, where the finest kinds of pottery is produced, and he made good. The accompanying illustrations show several scenes in the clay modeling class.

Besides the important purpose of keeping the children off the streets, the classes in these settlement institutions secure an invaluable result in teaching the children how to think, a matter too seldom accomplished in the great public schools, where instruction is attempted in such an endless number of different subjects that the work becomes largely a matter of rote and memorizing, with little understanding of the principles involved.

The Cultivation of Caraway

AMONG the various aromatic plants cultivated as a regular field crop in Europe is the caraway. It belongs to the group of umbelliferous plants of which the carrot, celery, fennel, cumin and anise are members. Botanists refer to it under the name of *Carum carvi;* but its English trade name is common caraway; the French call it semences de carvi and in German it is known as kümmel. The origin of the name caraway is the Roman word *carvi*, which was adopted very early by the old Spanish as *alcaravea*, and has since been modified to the present form.

The caraway plant resembles in many respects the wild carrot with which one is familiar. It reaches a height of 2 to 3 feet, bearing umbels with little yellow flowers which develop into fruits corresponding in general character to those of the other plants of this large family of plants. The fruits, incorrectly called seeds, are about 1/6 inch in length and 1/20 inch in diameter and are somewhat horny and translucent. When crushed, they give off an agreeable fragrance and a warm pleasant aromatic taste. The leaves possess similar properties and afford an oil identical with that of the fruits. The roots are partly fleshy not much unlike that of the wild carrot and are said to be better eating than the parsnip.

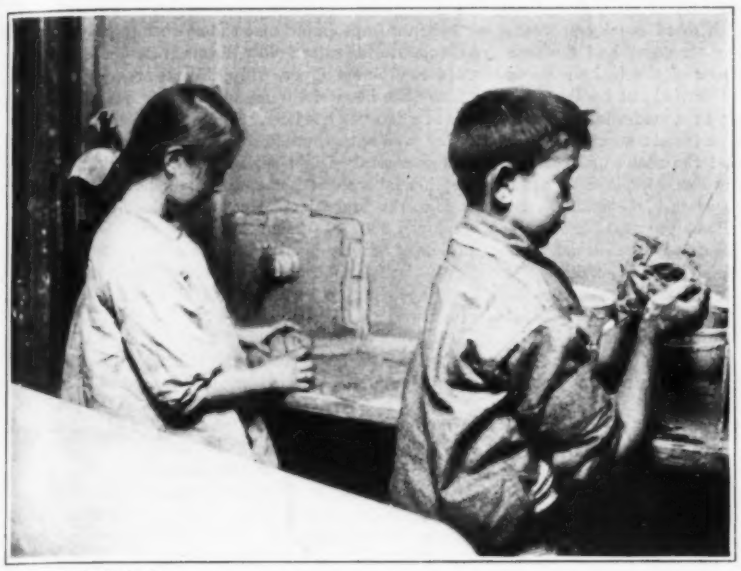
One marked peculiarity about this plant is that it is indigenous to all parts of Europe, Siberia, Turkey in Asia, Persia, India and northern Africa and yet is cultivated only in a few comparatively restricted areas. It grows wild in many parts of Canada and the United States, but is nowhere grown as a field or garden crop. Its cultivation is restricted to relatively small areas in England, Holland, Germany and Morocco, where it constitutes one of the chief agricultural industries within its narrow confines. The chief English cultivation of the plant is in Essex, Kent and Suffolk, where it is grown upon old grass land broken up for that purpose. Here it is generally sown with another plant of the same family as coriander, and sometimes a crop of teasles (*Carduus fullonum*) is raised on the same land.

Holland has practically a world monopoly in the cultivation of this important crop. The small efforts that have been made to grow it in other countries have thus far been without much appreciable success when compared with the high state of the industry in Holland. It is cultivated most intensively in the provinces of Groningen and North Holland in which more than half the acreage is found. In the whole country about 20,000 acres are devoted to this crop, each acre yielding about 1,000 pounds. This makes the total annual yield approximately 20,000,000 pounds.

While caraway is grown commercially throughout Germany, Austria, France and parts of Spain, the character and amounts produced are very variable, and the yield per acre varies only from 4 to 700 pounds. These countries do not produce much more than what they require for home consumption. Morocco produces a grade of caraway that comes regularly into the English and American markets, but it is somewhat inferior in quality. The Dutch caraway is preferred among consumers in this country and the bulk used here comes from Holland. The amounts and values of caraway shipped into this country from all sources during the last three years ending June 30, 1915, are as follows:

Year	Amount	Value
1913	3,691,831 pounds	$234,294
1914	1,909,300 pounds	107,599
1915	2,895,418 pounds	172,742

The fruits of the common caraway have been known and valued since the earliest historical times for at least some of the many useful qualities which make of it an important article of commerce today. It is believed that the use of caraway originated with the ancient Arabs. Since that time it has been used in large quantities in some countries in cookery and in all to more or less extent for medicinal purposes and for flavoring confections, wines, cheeses, etc. Its former wide employment in medicine has much decreased during recent years. It was employed at one time as a carminative, cordial and stomachic and was formerly recommended in dyspepsia and symptoms attending hysteria and other disorders. It is still used more or less successfully as an aromatic stimulant, but its chief use is for flavoring pastry, confectionery and sauces; the oil is used as an ingredient of alcoholic liquors.



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Kneading clay into condition

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First lessons in shaping clay

Probable Immigration After the War*

The United States Will Be the Promised Land for Hosts from the European Armies

It begins to look as if the whole question of immigration and the handling of European labor may soon have to be worked out again, and as if American railways and industrial companies would soon have to look upon this old problem in a new light and prepare to deal with it in new ways. There is every reason to believe that with the end of the war and the disbanding of the vast fabric of armies built up because of hostilities, there will be an unprecedented rush of labor to the United States. One may say what he will about the amount of labor that will be needed for the reconstruction of Belgium and northern France or to rebuild the destroyed portions of the German, Russian and Austrian frontiers. We may say what we will about the many thousands of men and women that will be required for agricultural pursuits, for the new industrial plants of Europe. But it is a fact that the people of Europe will have their eyes on the United States and will attempt to get there to recoup their fortunes.

The United States will be once again their promised land. Soldiers, women, civilians, and all the people I talk with insist that the United States has become fabulously rich by this war, and many of them have told me of their intention to go there so soon as they are permitted by the end of the war. So widespread is this feeling that it is already asserted that the governments of Europe will work in harmony with that of the United States to prevent this flux of labor from becoming too great.

This is not the expression of my opinion only; it is the result of talking with American diplomatic and consular officers in Europe. Should hostilities cease this summer, they say it would not be surprising if the year 1918 saw our immigration reach the huge total of 2,000,000; almost twice that of the banner year 1907. The only check to this immigration will be our own laws and those of the respective European governments.

But the character and quality of this new immigration are going to be very different from any that we have yet had in our history. The literacy law of the United States which goes into effect May 1st will not determine the character of this immigration. As was shown in Italy some years ago when such a law appeared to be about to pass under the Taft administration, an unlettered man or woman can be taught to read and write well enough in three to five months to pass the test of the new law. The law will not long shut out the honest but ignorant peasant. The new immigrants coming to us will be laborers who have graduated from the armies, men who have fought for six months, a year, two and even three years, along the various fronts, or worked in the munition factories.

The manhood of Europe has received a training in hard labor, in habits of sobriety and in discipline that may make it invaluable to employers. Just as those foreigners among us who worked on our railroads, in our subways, in our factories, in all our work of construction, became unusually useful in the armies which they left us to join, so these new immigrants will have been educated for us along the same lines. Further, we may be particularly sure of the quality of the man who, guided by a sense of decency and self-respect and patriotism, left us without compulsion to fight in Europe and who, his duty done, returns to us once more.

Employers will not have to fear from these army graduates any wild spirit of lawlessness bred by military service. Military discipline in these armies has, on the contrary taught the men self-control, obedience, and cheerfulness in the face of hard work. It has rubbed off the disagreeable corners of their characters. It has even forced them to eat little, sleep lightly, and go far without complaint, indeed accept wounds and death itself with calm philosophy. Whatever of rowdiness, of swaggering, of drunkenness there was among these soldiers at the outbreak of the war has long since been ground out of them. It is only the "tin" soldier who clings to such veneers of war. If he might, an employer should make an honorable army or navy discharge, a requisite for the employment of these new laborers.

There should rather be the fear that the war, instead of breeding roughness and disobedience among these men, should in some cases have broken down their sturdy self-reliance, as for instance with men of the Serbian army I saw after they had come over the Albanian mountains. The hardships, the hunger, the panic had left them physical wrecks, and their six months of recuperation at Corfu was not sufficient to rebuild them. Physically they looked all right but I knew their spirit was gone.

How will the American employer of labor handle these sons of the armies, these men who have had a life education of engineering, of mechanics, of plain work and vast suffering compressed into the narrow space of a year or two at war?

Will he permit them to be herded like cattle into his factories, about his yards, his place of work? Will he shut his eyes to their exploitation by their own countrymen who parade as foremen? Too often this was the treatment accorded the labor which came among us during the past dozen years.

If the employer continues as of old he will not only add to our well-nigh unsolvable national immigrant problem, to the miseries of these work people and to his own labor problems, but, he will also lose a good part of the immediate efficiency of these efficient laborers. Should he decide against the old method, he will take the trouble to study the organization methods which are today holding together these immense bodies of men in Europe and leading them to insurmountable tasks and to the accomplishment of work undreamed of in the lexicon of labor.

It must not be thought that these armies are held together by the force of the military spirit. It is by the mere force of organization, and this organization has at its bottom the good, fancied or real, of every one of its members, and in each army organization there is a recognition of the human, racial qualities of each group. Thus, the German organization is a stiff one; results in fighting and work are gotten by implacable brutality. But in the French and Italian army organizations results are gotten by treating men kindly, by officers accepting soldiers as their equals, and by persuading, stimulating them to their tasks, all the while letting the reins of discipline seem loose.

An Italian general once undertook to explain to me his apparent lack of discipline. Soldiers were passing by, saluting and smiling to him at the same time, in a manner that was more friendly than respectful. "If those fellows were Germans, I couldn't let them smile in my presence and ever hope to get any work out of them again," he remarked. "But if I did not smile and seem slipshod in my discipline with my men, they would appear to be working but yet not working. These Italians of mine know that I and every officer have their good at heart. We don't ask them to do things we wouldn't do ourselves, and we sometimes do things as an example that we don't ask them to do. Then they do them of their own accord."

As the Italians will come to the United States in greater numbers than any other nation in Europe, they having suffered less in man loss from the war and certainly as much, relatively, in money losses, it would be well to consider their character.

The character of the Italian workingman, or peasant, can be put down in a few words. He has but one big fault. He is sensitive to reproach, quick to offense. Therefore his is among the most democratic of nations. He is lazy, perhaps, in the southern parts of his own country, but under the stimulus of a colder climate this southerner quickens in his work.

Generally the Italians themselves make distinctions between the man from the north and the man from the south. The man of the north, of the regions of Milan and Turin, lives in a cold climate, is hearty, industrious, wealthy, ingenious, and as such is the backbone of Italian life and progress. It is the peasants of these provinces of Lombardy, Piedmont and Liguria that constitutes about one-third of the 600,000 emigrants of Italy that annually go abroad to the Argentine, to France, to Austria, to Germany, and to the United States, nearly one half or some 280,000 going to the United States. But those northern province emigrants generally go abroad to work during the seasons when there is no work for them at home. Their character has never formed a problem for any employer who has taken the trouble to distinguish them from the Italians of the south and who treats them with common decency.

It is the immigrant of the provinces further south who must be studied. His employer must never hold the idea that this immigrant is a natural born thief, murderer and liar. He was in some degree these things many years ago when he lived under almost feudal conditions and was treated by various over-lords as something of a slave. The impressions he has given of these qualities among us has been partly due to the fact that the Italian government, in its efforts to get rid of the Camorra, the "black-hand," and other societies, which had their origin in the feudal system, has not been averse to permitting its bad men to emigrate to and continue their work in foreign lands.

Seen at home, as I have seen the average southern Italian, he is simple, accommodating, unmoral, (not immoral), unreligious though a church-goer, not very intelligent, happy-go-lucky, easily flattered, quick to

*A letter from its European correspondent to the *Railway Age Gazette.*

respond to kindness, fearful of unfair treatment, patient, reasonably hard-working, and—above all—sober. His food is macaroni (or some form of this flour paste), fruit, meat, cheese, bread and wine; and this food he is ready to divide, if he be a peasant, with all comers. In the third class compartments of the trains where the peasants ride, particularly the laborers who have special rates to travel from one district to another, in the course of their work, there exists the old-fashioned spirit of hospitality. American art and architectural students who travel a great deal in all Italy have told me that they have the greatest difficulty in refusing the rough food proffered them by these kindly peasants.

Strange as it may seem Italians of all classes have a way of speaking poorly of each other. Thus, Rossini once said: "Whenever an Italian sees a Spaniard, he should embrace him; for if it were not for the Spaniard, the Italian would be the lowest race on earth." Of course, this remark is witty but it is not fair. The poorest of Italians is charitable. If he has two cents, he will give one of them to the first beggar he meets; which explains why begging has become a trade in Italy.

In dealing with these big children, perhaps the first American reform necessary is to get away from the feudal "padrone" system, which so effectually prevents any direct relation between the employer and the man employed. The construction jobs of the United States in the past have generally been carried out by the engineer or contractor telephoning to a padrone, "I want five hundred or a thousand men for six months," after which a lump sum is paid, and the real employer has nothing further to do providing the work is done as he wishes. In railroad work the system is much the same. The Italian laborer, or the Pole, or whatever he is, generally does not know the name of the railroad he is working on and is not interested. He is working not for the railroad, in his mind, but for the padrone, the "boss," who generally manages to exploit him in his wages, his food, even his clothing, and if he rebels, the best satisfaction he gets is a discharge on the spot. One way to break up the padrone system is to have trusted men speaking the native language of the gangs. The viciousness of the contract system has been pointed out again and again, and it has been emphasized that the real employer can never hope to profit by the past training of the individual laborer, or by the particular training the laborer acquires while doing the immediate work before him.

It is not improbable that the new army graduates will not tolerate the rotten old padrone system and that they will force the employer, willy-nilly, to wake up, to speed up, to take heed of the organization forces under which this new laborer has been schooled.

The man with the labor of his hands to sell may soon occupy a strategical position. Italy is going to try to keep her laborers at home, although she may urge them to go to the Argentine. Germany, which before the war employed 800,000 foreign laborers a year, will certainly, in view of her manhood losses of the war, offer a fair field for the foreign laborer during her reconstruction and the vast speeding-up process of all-around commercial expansion.

England may offer a good field for her native labor, though the part woman is now taking there promises to help drive labor America-wards. It is also a fact that in view of the anticipated rush towards the United States, Europe really fears a yellow labor peril, and will do much to block emigration.

Such facts are but further arguments to induce the American employer of labor on a large scale to intensify his welfare plans which at present apply more at the top than at the bottom of the labor ladder.

Steel and Steel Alloys*

The Relationship Between Steel and Iron

By G. N. Pingriff, B.A., B.Sc., F.C.S.

THE starting-point in all work connected with the manufacture of steel is the crude product of the blast furnace, which is run off periodically as a stream of white-hot metal. It is not pure iron—its impurities vary according to the nature of the ore from which it has been obtained—but on solidification it constitutes what is known as either pig-iron or cast-iron. Before considering this further, however, it will be well to fix our ideas as to the nature of pure iron. We shall then have a standard by which to judge either cast-iron or any of the other commercial forms of the metal with which we shall meet in the sequel.

Pure iron is an almost white metal of specific gravity 7.86, which takes a high polish and is one of the most tenacious of the ductile metals. It softens at red heat, can be easily welded at white heat, melts at about 1,550° C., and boils at about 2,950° C. It can be easily magnetized, but easily loses its magnetism again. Its crystalline structure can be seen under a moderately powerful miscroscope, and it is believed to exist in three different allotropic forms. Chemically, it is a fairly active element; thus in the presence of air and water it undergoes oxidation, or rusting, and in the molten state it has the power of combining with carbon and certain other elements. It also has the power of dissolving these elements—not the same thing as combining with them—and of mixing with other molten metals of a similar chemical nature to itself. The commercial form of iron which most closely approaches pure iron is that known as wrought-iron. Indeed, the finest kinds of piano wire often contain as much as 99.7 per cent of the element. Absolutely pure iron can be obtained, though not very easily, by electrolytic deposition from solutions of certain of its salts; it is of little or no practical importance.

To return then to our starting-point, let us proceed by considering how far the crude pig-iron from the blast furnace differs from the pure iron just described. In the first place, the pig-iron melts at a much lower temperature, about 1,100° C.; in the second, it has none of the malleability or ductility of the pure iron, and thus cannot be worked under the hammer; and in the third place it usually shows at a freshly fractured surface either a gray or mottled appearance. These are the chief physical differences, and they can mostly be accounted for by the results of a chemical and microscopic examination of the iron. Thus the analysis reveals the presence of from 2.2 per cent to about 5 per cent of carbon and varying amounts of silicon (an element in many respects resembling carbon), phosphorus, sulfur and manganese. It also shows that part of the carbon is present in a combined form as carbide of iron—chemical formula, Fe_3C.—and part, especially in the gray cast-iron, in the uncombined form of graphite. The former accounts for the unpleasant smell produced when the iron is dissolved in, say, dilute sulfuric acid, and the latter for the deposition of black powder during the process. As much as 3 per cent of silicon may be present in the cast-iron, while the percentage of manganese may be many times more. Alloys containing more than 25 per cent of manganese are known as "ferro-manganese," and are speciallly prepared for use in the manufacture of manganese steel (*v.* later). The results of some typical analyses of cast-irons are given in the table below as percentages; it will be seen from these how variable are the amounts of the different impurities:

—	Graphite	Combined Carbon.	Silicon.	Sulphur.	Phosphorus	Manganese.
Grey Iron (Staffs.)	3.3	40	1.88	.02	.71	.40
Mottled Iron (Cleveland) ..	2.28	.72	1.35	.03	1.17	—
White Iron (Durham)	—	4.10	·23	.03	.07	2.37
Spiegel (Westphalia)..	—	5.04	·41	.08	—	5.75

Analyses of Typical Cast-irons.

From cast-iron wrought-iron is obtained by various processes, all of which consist essentially of the purification of the cast-iron. As has been mentioned, wrought-iron is for all practical purposes pure iron, and its properties closely approximate to those described for the pure metal. It is important to note, however, that during the process of manufacture the iron is not actually melted, as is the case in the manufacture of both cast-iron and steel. It is in this respect indeed that wrought-iron differs primarily from steel, and for the same reason the iron is generally found to have a definite fibrous texture and not infrequently to contain particles of slag, which make their appearance in the finished article. The other respects in which steel differs from pure iron are, firstly, that it contains, like cast-iron, varying amounts of foreign elements, and, secondly, that it has quite different physical properties. These will be described later.

THE MANUFACTURE OF CARBON STEELS

Ordinary steel usually contains less than 2 per cent of carbon, while, as we have seen, cast-iron contains roughly from 2 per cent to 5 per cent of this element. Further, steel does not usually contain more than mere traces of phosphorus and sulfur, and seldom more than 0.1 per cent of silicon. Evidently, then, in manufacturing steel from cast-iron, which is the usual order of procedure, it is necessary to remove the impurities of phosphorus, sulfur and silicon, and much of the carbon. Various ways of doing this have been utilized at different times and in different places, but nowadays the bulk of the steel produced is made by one or other of the three general methods following:

1. The cementation process.
2. The Bessemer process.
3. The open-hearth process.

The principle of the cementation process is that of first removing the whole of the carbon and other impurities of the cast-iron, and afterwards heating the wrought-iron so obtained with charcoal or soot for a number of days. During the heating the iron takes up the requisite amount of carbon, thereby becoming converted to what is known as "blister steel," and this is lastly melted in large plumbago crucibles and cast into ingots. A modification of this process, which was first carried out on the large scale by Krupps, of Essen, consists of direct fusing in the crucible of wrought-iron bars to which has been added the requisite amount of a cast-iron, such as spiegel, with a high percentage of carbon. Steels so prepared are known as crucible steels.

During the last fifty years the cementation process has been largely displaced by the other processes named above. (Compare figures in the table.) The new principle involved is that of burning away the impurities of the cast-iron in a blast of hot air. In the acid Bessemer process the "converter," which is a huge iron crucible mounted on trunnions, is lined with sand (*i. e.*, an acid oxide, SiO_2). The base of the converter is fitted with a false bottom, and through this the air blast can be forced. The molten pig-iron, brought direct from the blast furnace, is run into the converter and the blast at once started, with the result that the carbon and other impurities burn away as gaseous oxides, and in so doing supply sufficient heat to keep the mass molten. When, after fifteen minutes or so, the flame shows that the impurities are sufficiently removed, the blast is stopped, carbon in the form of a high carbon alloy is added and mixed with the molten metal, and, lastly, the steel is poured out in a white-hot stream into "ladles," from which it is cast into ingots. In the basic Bessemer process the procedure is much the same, save that the converter is here lined with basic oxides (lime and magnesia) instead of with sand, the advantage being that the phosphorus of the cast-iron which is not removed in the acid process is now completely eliminated as "basic slag." The Bessemer process itself dates from 1856, while the introduction of the basic process is due to the work of Thomas and Gilchrist in 1879. The introduction of the basic treatment for phosphorus containing ores has proved almost as great a revolution as that of the Bessemer process itself.

But at the present time steel is produced in still greater amount by the open-hearth process. The chief difference between this and the Bessemer processes is in the form of the furnaces used. These have a capacity of 75 tons, compared with about fifteen tons of the Bessemer converter, and are heated by either producer gas or sprayed oil used in conjunction with an ingenious regenerative system invented by Siemens; the change also is much slower, and therefore more under control. During the heating the metal appears to boil, an appearance due to the escape of gaseous oxide of carbon. As soon as a test shows that the steel contains the necessary amount of carbon the heating is stopped, any other necessary ingredients, such as aluminium or titanium added, and the steel cast into ingots. Aluminium and titanium are known as "steel purifiers," and must not be confused with the other metals which are added, as will be described later, to form definite alloys. Aluminium removes oxygen from the metal and titanium both oxygen and notrogen. Both basic and acid open-hearth furnaces are used, and the steel obtained from these is generally preferred to Bessemer steel for the construction of railway bridges, shafts, big guns, and in

*From the *English Mechanic*.

all cases where the steel is to be subjected to much vibration. Electric furnaces are also coming into use for the manufacture of steel in places where electric power is cheap, but the only new principle involved is in the mode of heating.

The figures in the following table show the relative amounts of steel produced by the three principal steel-producing countries of the world by each of the above-mentioned processes. The figures where available are given for both 1913 and 1914:

—		Bessemer		Open Hearth.		Other Processes.	Totals.
		Acid.	Basic.	Acid.	Basic.		
United Kingdom	1913	1,049,000	502,000	3,811,000	2,252,000	Returns not available	7,614,000
	1914	797,000	462,000	3,561,000	2,875,000		7,695,000
Germany	1913	—	—	—	—	—	19,930,000
	1914	115,000	8,397,000	344,000	6,079,000	104,000	14,949,000
U.S.A.	1913	2,546,000		1,266,000	10,345,000	155,000	31,300,000
	1914	6,221,000		904,000	10,791,000	397,000	33,313,000

The production of steel in 1913 and 1914. The figures for Germany are in metric tons, those for United Kingdom and United States of America in English tons (the English ton is slightly larger).

THE PROPERTIES OF STEEL

We have already considered the properties of both cast-iron and of wrought-iron; let us next consider to what extent the manufactured steel may be said to differ from either of these. Briefly, steel differs from wrought-iron in that it has been formed by solidification from the molten state and from cast-iron in that it can be hammered out, rolled, and drawn into wire. To watch the rolling machines at a steel works shaping the blocks of hot steel into steel rails is a process which can never be forgotten. Yet, in spite of its malleability steel can, by suitable treatment, be given almost any degree of hardness—from that of wrought-iron to almost that of diamonds. Further, the tensile strength of steel is far higher than that of pure iron. (The tensile strength or tenacity is usually measured by the weight, in kilograms, required to break a wire of one square millimeter in area. For lead it is 2.6 kgms., for copper 51, for iron 71, and for steel 91.) Lastly, steel can be magnegatized in the same way as ordinary iron, but, unlike the iron, it has the power of retaining its magnetism with a considerable degree of persistence.

Of all these properties perhaps the most interesting is that which refers to the different degrees of hardness. If a steel contains much carbon, say 1.5 per cent, it can be hardened by being suddenly chilled from a white heat, as by immersion in a bath of oil; it can then be tempered or "brought down" by subsequent reheating. To attempt to understand this it must be noted that the carbon in the hot steel is partly in the form of the carbide of iron, Fe_3C., and partly in the form of the element, but that in either case it is dissolved homogeneously throughout the iron. On sudden cooling the mass remains practically homogeneous in the form of a solid solution, but during slow cooling various changes proceed in the mass of the iron. In particular the carbide separates out in the form of minute hard crystals known as "cementite." At 700° C. or thereabouts other important changes occur, with the final result that slowly cooled iron is not homogeneous, but, on the other hand, exhibits a somewhat pearl-like appearance under the microscope, and consists essentially of crystals of hard cementite embedded in soft crystals of iron ("ferrite") The whole subject is one of great difficulty, and metallographists are by no means agreed as to the interpretation of the different effects which are noticed, but from this account the reader should be able to obtain a general idea as to the nature of the changes which occur.

It was mentioned earlier that steel must not contain more than the merest traces of phosphorus and sulfur owing to the embrittling effect attributed to these elements; much sulfur makes the metal brittle at a high temperature—"red-shortness"—while phosphorus produces "cold-shortness." But analyses of the fragments of German shells which were picked up after the bombardment of Hartlepool showed far larger amounts in these elements than was allowed in British specifications. Since then the matter has been investigated, and quite recently a paper was read before the Iron and Steel Institute by Dr. Stead, in which it was pointed out that, contrary to the previously held opinion, reasonable amounts of phosphorus may have an undoubted beneficial effect in giving hardness to the steel. Similarly, moderate amounts of sulfur may also be allowed provided that sufficient manganese is also present. Such facts are, at the present time, of the utmost importance, for raising the limit of the allowable proportions of these elements makes a great difference to the possible output of shell steel for war purposes.

OTHER STEEL ALLOYS

Carbon steels are usually regarded as alloys, although, of course, carbon is not a metal, but, besides these, there is a large number of true iron alloys which have come into extensive use during recent years. We will therefore conclude by considering the most important of these and the special properties to which their importance is due. Most of them are manufactured by adding the second metal, in the form of a rich iron alloy, to the molten steel just before it is run out of the furnace or converter.

MANGANESE STEELS

Manganese is a metal which in the pure state closely resembles cast-iron in appearance; it undergoes oxidation more easily than iron and melts at a somewhat lower temperature. Manganese steel—also known as Hadfield's steel—usually contains from 11 per cent to 14 per cent of manganese and 1.5 per cent of carbon. It is extremely hard and brittle when first cast, but the brittleness can be removed without affecting the hardness by reheating and quenching. The finished alloy is exceedingly tough and is largely used for the jaws of rock-breaking machinery, for railway points and for safes; it cannot be softened by any known process. The chief source of the manganese for the production of this alloy has for long been the German spiegeleisen already referred to, but recently the Ebbw Vale Steel Company has produced a manganese alloy far richer in the metal than is spiegel.

CHROMIUM AND TUNGSTEN STEELS

Chromium is a hard, white metal, which melts at a higher temperature than iron. It is generally met with in the form of "ferrochrome," which is obtained by the electric reduction of a chromium iron ore. Tungsten is similar, but melts at a still higher temperature—about 2,800° C.; it is the metal which is used in most incandescent electric lamps. Chromium steels containing up to 13 per cent of chromium, are coming into use for table cutlery under the name of "rustless" or "stainless" steels, but the most important chromium steels contain a third metal, such as nickel or tungsten or one of the comparatively rare metals molybdenum or vanadium. Chromium tends to increase the hardness of steel, while molybdenum and tungsten prevent the softening effect of increased temperature. Steels containing 6 per cent of chromium, together with about 10 per cent of tungsten or molybdenum, are much used for high-speed lathe tools. The use of tungsten steels in the United States is said to have greatly increased the ratio of output to wages. Further, it is interesting to note that the manufacture of tungsten in this country is one of the successful minor industries directly attributable to the war. The "High Speed Steel Alloys Company," of Widnes, has purchased mines in Burma, and is now producing large amounts of a very rich tungsten alloy. Tungsten steel is also much used for magnets on account of its high retentivity for magnetism.

NICKEL STEELS

The chief effect of nickel is to increase the tenacity and elastic limit of the metal without reducing its ductility. Vanadium acts in the same way, but is more effective, 0.2 per cent of the latter metal producing the same effect as 3 or 4 per cent of nickel. A nickel steel containing 3½ per cent of nickel, as well as sometimes the same amount of chromium, is much used for armor plates, projectiles, wire cables, and propeller-shafts. Nickel steel containing 36 per cent of nickel is of interest as being the alloy with the lowest known co-efficient of expansion. It is sold under the name of "Invar," and is used in the construction of pendulums and certain exact measuring instruments. With 42 per cent of nickel the alloy has the same co-efficient of expansion as glass; it is then known as "platinite."

VANADIUM STEELS

The effect of vanadium has been mentioned. Ferro-vanadium, from which the steels are made, costs about 15s. per pound of vanadium contained in it. Vanadium steel is especially valuable where the metal is subjected to alternating stresses; it is sometimes known as "anti-fatigue metal." An alloy containing 1 per cent of chromium and 0.15 per cent of vanadium is used for connecting-rods, axles of automobiles, springs and in aeroplane construction.

COPPER STEEL

Copper steel is used in the United States for roofing purposes. It is claimed to be very resistant to corrosion, while aluminium, platinum, tin, tantalum and uranium steels are at present only of experimental interest.

First Aid to Wounded Trees*

By J. J. Levison, City Forester of New York City

EVERY owner of an estate with trees on it has the problem of tree wounds to consider. Every city has streets with horse-bitten trees on them and everyone owning even a single tree may some day find its bark injured by the milkman's horse, by the neighbor's automobile or by some mischievous school boy.

When the bark is thus injured, a tree can no longer produce the proper amount of foliage or remain in a healthy condition very long. The reason for this is clear when we stop to consider the nature of the most important tissue of a tree—the "cambium layer"—and note how it becomes affected by such injury. The cambium layer is a thin tissue located immediately under the bark. It must completely envelop the stem root and branches of the tree. The outer bark is a protective covering to this living layer, while practically the entire interior wood tissue is composed of dead cells and merely serves as a supporting skeleton for the tree. The cambium layer is the real growing part of the tree. It is the principal part which transmits the sap from the base of the tree to its crown; it is the part which causes the tree to grow by the formation of new cells, piled up in the form of rings around the heart of the tree, and it is also the part which prevents the entrance of insects and disease to the inner wood.

From this it is quite evident that any injury to the bark and consequently to the cambium layer just beneath it will not only cut off a portion of the sap supply and hinder the growth of the tree to an extent proportional to the size of the wound, but will also expose the inner wood to the action of decay.

It may be a small wound and may appear unimportant, but if neglected it will soon commence to decay and carry disease and insects into the tree. The tree then gradually becomes weakened, hollow and dangerous, and its life is doomed unless repairs are made.

If the wound is dressed in time recovery is certain; or if a suitable guard had been placed around the trunk of the tree before the injury occurred, serious damage could have been avoided.

The most serviceable guard is made of wire netting, ½-inch mesh, No. 16 gage and cut to a height of six feet. There are many other forms of tree guards used; some more elaborate and expensive than others, but none more efficient. The wire netting guard has the advantage over the others in adapting itself to the tree when it grows in thickness.

In spite of efforts to protect the bark of trees, bruises, cuts and tears occur, and in all such cases the wound must receive immediate and careful attention. Any attempt to force the loose bark to grow back to the tree will fail. In dressing the wound the rough edges of the injured bark should be cut smooth and the exposed wood covered with coal-tar. Coal-tar by itself or in mixture with creosote has an antiseptic as well as protective influence on the exposed wood. Not only for these reasons is it far preferable to paint for covering wounds, but also because it has the advantage of being more lasting and does not peel as paint does.

Some people bandage the bruise of a tree with burlap or cloth. This is not advisable because disease will set in more readily under the protection of a bandage than it would when the wound is freely exposed to the air. For the same reason the method of covering wounds with tin is equally bad.

When we consider the care required in the treatment of a tree bruise, does it not seem that we are expecting a great deal from the trees that we plant along our city streets? We plant them in a cement pavement, alongside of a deep set curb-stone, with more pavement on the street surface and leave them to draw food and water from the hard packed clay. Then the bark may be injured, the direct channel for sap supply cut off and still we expect them to survive and wonder why they do not.

American Forestry.

Isolation of a Growth-Producing Substance from Sheep Pancreas

SHEEP pancreas was extracted with alcohol containing 4 per cent of HCl, the extracts were evaporated at a low temperature, the residue was dissolved in water, the solution filtered, the filtrate evaporated, then diluted with water, treated with sulphuric acid and phosphotungstic acid, the precipitate collected, decomposed by mixing with water and barium hydroxide, and the mixture filtered. After removing excess of sulphuric acid from the filtrate, the latter was evaporated, the residue treated with alcohol, and the alcoholic solution treated with alcoholic mercuric chloride solution. The precipitate obtained was decomposed with hydrogen sulphide, the mercury sulphide separated, and the purines in the solution then precipitated with silver nitrate and separated by filtration. The filtrate was treated with silver nitrate and barium hydroxide, the precipitate formed was decomposed with hydrogen sulphide, and the solution freed from barium, sulphuric acid, and chlorides. The resulting solution contained a substance which was capable of producing a marked increase in growth when administered to rats. The substance was precipitated by phosphotungstic acid and by colloidal hydrated aluminum silicate (Lloyd's reagent); it was not a protein, fatty substance, or a mixture of amino-acids. —W. H. EDDY "Jour. Biol. Chem." From a note in the *Journal of the Soc. of Chemical Industry.*

An Electrical Boiler Water Level Recorder

THE accompanying illustrations show an electrical boiler water recorder recently developed. It records the level of boiler water on a chart, showing its position at any instant relative to the economical line, the danger line or the wasting line.

This instrument is intended to safeguard against loss in coal wasted due to too much water, insure against explosions and repairs from too little water, and show at every minute how nearly the point of greatest economy is approached. Wires connect the contact chamber on the upper part of the water column with the dial mechanism.

There is a float in the water column with a rod attached to it which extends up into the contact chamber, which, as the float raises or lowers with the level of the water, makes a contact with the terminal plugs. The connection thus made transmits the current to corresponding magnets in the dial mechanism which operates the pens. It is of interest to note that the float, which is a vital part of the device, is reinforced and made non-collapsible by using light copper and reinforcing it with inside pressure through the use of compressed gas. The nominal pressure of the gas sealed in the float is raised automatically up to the heat of the boiler, so that the pressure inside the float will equal the steam pressure outside at all times, thus leaving the stress on the walls of the float practically neutral.

It is said that this instrument will record the water level correctly on the dial, and if the container is empty or full, the alarm will ring. The bells may be placed at the back of the boiler at the blow-off valves, and will give the same warning as on the recorder. If desired the apparatus can be installed with motor valve attachment to the feed pump, to start the feed pump when the lower water point in the boiler is reached, or it can be made to act as an automatic regulator and keep the water at all times to the level of any of the terminals desired.

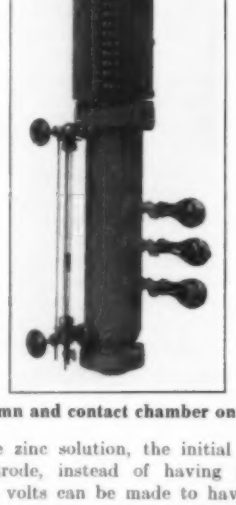
This instrument not only records the level of the boiler water at all times, but it also shows where it is and has been, and the time it was at that level and whether on the economical line, the danger line or the wasting line. The dial may be placed in the office at a distance from the boilers and it will safeguard against the loss of thousands in coal wasted from too much water. For each 100 horse-power per year with cost of coal at so little as $1.50 per ton the cost should approximate $5,000 for the necessary coal, depending on the type of boilers—and assuming that water is carried on the economical line.

It is pointed out that every horse-power generated requires 1 cubic foot water per hour and, every horse-power requires also 2 cubic feet steam space per hour. If boilers are filled with water there is a decrease in the efficiency of the heating surface required for each cubic foot water and it contracts the steam space, lowering the efficiency of the installation and thereby burns more coal and produces less steam.

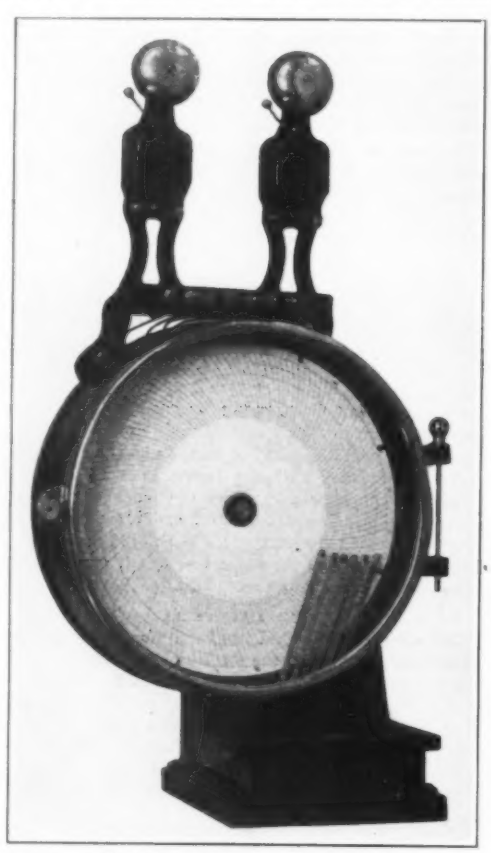
Again, if too little water is carried one has excessive repairs or an explosion. Everyone knows these things and yet will admit they have found the general tendency to have been more often in one or the other direction, rather than at the right point, and that for the most part they have been powerless to positively correct it. The results from even slight deviation are tremendous.

It is well known that there is an economical line at which to carry water. Why hasn't it always been carried there? Regulators have not done it, and flow meters do not do it—of as much assistance as both are. It is because the human factor has been responsible, and until now there has been no practical recording instrument with which to check that human factor.

If one is carrying three inches too much water it means in one year a loss of efficient time of 25 per cent, or the equivalent of 18 running hours instead of 24. It means also more than 25 per cent too much coal consumed.



Water column and contact chamber on the boiler



Water level recording instrument

The Electrometric Titration of Zinc With Ferrocyanide*

By F. Russell v. Bichowsky, Geophysical Laboratory

THE purpose of this note is to point out a set of very interesting polarization phenomena that occur at a platinum electrode when certain insoluble salts, such as zinc, ferric copper, lead, or manganous ferrocyanide, are being precipitated. Only the case of zinc ferrocyanide will be discussed here.

If we place a platinum electrode in a solution of potassium ferrocyanide and titrate this solution with a solution of some zinc salt the e.m.f. of the electrode measured against some standard electrode, such as the normal calomel electrode, follows a perfectly normal curve beginning at about −0.08 volt (the e.m.f. of the ferrocyanide electrode) and increasing slowly with the addition of the zinc solution until near the end point; on the addition of a drop in excess of the amount of zinc solution necessary to precipitate all the ferrocyanide the e.m.f. increases very sharply to −0.40 volts. With further excess the e.m.f. stays approximately constant, reacing a maximum value of about −0.45 volts. The electrometric end point is thus very sharp, and the platinum electrode is by all means the most accurate and convenient device for determining the end point of the zinc ferrocyanide titration.

However, if instead of adding zinc solution to a ferrocyanide solution we reverse the process and add ferrocyanide to the zinc solution, the initial e.m.f. of the platinum electrode, instead of having the invariant value of −0.45 volts can be made to have almost any value between 0.0 and −0.5 volts, depending on the previous treatment of the electrode. If the electrode has been allowed to stand in contact with a ferrocyanide solution for some time the e.m.f. will be between −0.1 and −0.25 volts, depending on the length of time it has been in the solution; if it is charged to say −2.0 volts while in contact with a zinc solution the initial e.m.f. of the electrode may reach the reversible value of −0.45 volts, or even higher.

If the electrode has been adjusted to an e.m.f. of −0.45 volts and the titration of zinc with ferrocyanide carried through as before, the exact reverse of the previous curve is obtained, the e.m.f. begins at −0.45 volts, drops sharply at the end point to −0.10 and continues at nearly that value on further addition of ferrocyanide. In this case, therefore, our initial curve is reversible. If, however, the platinum electrode has been treated so that it shows an initial voltage of say −0.20 volts, on adding the ferrocyanide solution the numerical value of the e.m.f. increases slowly, instead of decreasing, this increase continuing until the curve that is obtained by plotting e.m.f. against cc. of ferrocyanide added intercepts the normal curve. At this point the e.m.f is a maximum. From this point on the e.m.f. curve is entirely normal, the end point being perfectly sharp and unchanged. This phenomenon is similar to the one noted by Forbes and Bartlett[1] for the titration of ferrous iron with dichromate, but in our case not only is it possible to avoid the phenomenon entirely by the proper treatment of the electrode already indicated, but it is also possible not only to control the initial e.m.f. of the electrode, but also the shape and slope of the ascending (abnormal) part of the curve, thus causing the point of interception of the abnormal and normal curve to be varied. In a well stirred solution the abnormal curve starting at −0.2 volts will almost always intercept the normal curve just before the end point is reached, however, if the stirring is made very poor so that there is any large excess of ferrocyanide in contact with the electrode before the zinc is all precipitated, the end point can be suppressed entirely; or, if by various devices the titration is carried on so that the electrode is always in contact with small concentrations of both zinc and ferrocyanide iron, the point of interception of the normal and abnormal curve can be moved almost to the beginning of the titration, the titration curve thus having a very flat rather than the usual sharp maximum. Of course, in all these cases, except in the case of no stirring, the end point is perfectly sharp and reproducible, and under any of these varied conditions this method of determining the end point is much more rapid, convenient, and accurate than those employing the usual indicators (iron or uranium).

All these phenomena seem to show that in cases of this type depolarization can be accomplished only by some agent (in this case ferrocyanide, in Forbes and Bartlett's case, ferrous iron) whose oxidation and reduction reactions on the platinum electrode are reversible, and that the persistent irreversibility of the Forbes and Bartlett curve and of our curve was due simply to the fact that the only substance in the solution capable of rapid reversible reaction at the electrode was removed from the possibility of acting—by precipitation in our case, and by the excess of an irreversible strong oxidizing agent in Forbes and Bartlett's case. This explanation is independent of any theory of the cause of polarization.

*From the Journal of the Washington Academy of Sciences, communicated by Arthur L. Day.

[1] Journ. Amer. Chem. Soc., 35: 1527. 1913.

A Curious Use for Aniline Dyes

DR. ERWIN BAUMANN, a Koenigsberg (Prussia) surgeon, is using large quantitles of aniline dyeing materials for curative purposes, and has successfully treated over 400 patients with this novel medicament. As a germ-killer and arrester of noxious growths these materials are said to be far superior to any antiseptic substances so far known; they are quickly distributed, do not coagulate albumen, and, in the quantities used, are absolutely non-poisonous. They can thus be used in a very compact form, and their prompt destruction of all bacteria rapidly stops suppuration, heals wounded tissues, and causes a lowering of temperature.

Dr. Baumann at first used methylene blue, and subsequently methyl violet, which in most cases he found gave the best results. For burns, cuts, scratches, whitlows, abscesses, injuries to the skin of the head, and in many other cases the surface of the wound was painted with a 4 per cent dye solution, and (unless very dirty) the wound was closed up at once. If easily accessible, the wound was treated with the dye in powder form, while, in the case of deep wounds, a solution of the dye was worked up into a paste with glycerin, which, with the addition of a little alcohol, was then introduced into the wound by the aid of a small rod. If the wound is already deepened by cavities, antiseptic gauze is saturated with the dye solution and then carefully introduced into the cavity. Fistulous passages were treated by squirting the dye into them with a syringe. After one or two treatments, all formation of matter ceased, unpleasant odors disappeared, and the wounds dried up.

In the case of osseous suppurations—such for instance, as in osteomyolitis—the period of convalescence was greatly shortened. Also, in ventrical ulcers, appendicitis, abscesses, and the like, anilines were found to be of great value; suppuration rapidly ceased, and the cavities granulated and closed. Even on using as much as one gram daily, no harmful effect was observed. The injection was rapidly absorbed by the tissues, and subsequently left the body through the kidneys, upon which no prejudicial effect of any kind was exerted. Methyl violet gave excellent results in cases of suppurations in the pleural cavity, while methylene blue was found to be especially valuable for irrigating the bladder and destroying all bacteria and germs.—*The English Mechanic.*

Anomalies of the Animal World—Part III

Mammals That Lay Eggs and Present Other Extraordinary Characteristics

By R. W. Shufeldt

If there be one group of existing mammals more anomalous than another, the little fellows known as the Monotremata, of certain parts of Australia and the East Indies, are surely entitled to be placed at the head of the Class—that is, the Class Mammalia. After we become accustomed to an opossum, or, indeed, to any marsupial mammal, giving birth to her litter of young, at a time when it is hardly advanced beyond the embryonic stage of existence, and then placing the lot in her *marsupium*—an outside pouch in front of her abodmen—to be carried about there until they are developed, it does not seem so strange after all. This for the reason, as has just been said, that most people who take any interest in wild animals, either in nature or as pets, have long been more or less accustomed to this way of the opossums.

In the case of the monotremes, however, this phase in the matter of reproduction is even more remarkable—in fact highly anomalous, nothwithstanding the lucid explanation of the expounder of the law of organic evolution, who tells us that this phenomenon is no more than we should expect; for in the case of one of these strange little mammals, the Duck-bill, although it has as furry a coat as a muskrat, it exhibits in its anatomical structure, as we shall peresently see, some reptile and a whole lot of bird. What is so unusual about this Australian oddity is, that it lays eggs with as much equanimity as the most practical fowl in the barn-yard. This animal is unique in nature, and is being rapidly exterminated; the remaining family, represented by the Porcupine Ant-eaters or Echidnas, are hardly more numerous. These last, of which there are three very distinct species, occur in widely different regions. One is peculiar to Tasmania; another is an Australian species as well as Tasmanian, and the third is confined to certain parts of the vast island of New Guinea. These Echinas lay eggs as do the Platypus, but have quite a different way of caring for them. As a matter of fact, an Echidna and a Duck-billed Platypus are not only entirely different looking animals, but they are, anatomically, about as far removed from each other as are a bear and an African lion; their habits are entirely different.

Turning first our attention to the Platypus, we find it to be an animal that leads just as much of an amphibious life as our well-known muskrat or otter.[1] It is difficult to say for what reason, but the colonists in Australia call the Duck-billed Platypus the "Water-mole." It has no special affinity with the moles, nor does it resemble one in appearance. It inhabits the banks of rivers and lives upon certain insects, worms and molluses, captured along the low, muddy banks of its favorite streams. Soft, smooth and dense, its coat of fur resembles that of an otter, while its tail is flattened, short and covered with a peculiar bristly kind of coarse hair that grows in a curious, intercrossing manner. This tail reminds us of that appendage in a beaver, and we know that it is used in a precisely similar manner—as a sort of rudder in swimming.

With respect to the feet, we find all four of them as completely webbed as those of a duck or a swan; indeed, the webbing of the forefeet is so extensive that it projects beyond the large, sharp claws all round. A Platypus has small eyes, and this may account for its having been called a water-mole; while its most striking feature is its bill, which is broad and flat like that of some species of duck. (Fig. 17.) In fact it *is* like a duck's bill, with a frill about its base which is very sensitive. Instead of the well-known serrations seen in duck's beaks, however, the *Ornithorhynchus* has teeth of a very anomalous character. They are horny in structure, elongated, shart-edged and narrow in front, while those corresponding to the molars are flat and broad.

From time to time anatomists—and chiefly British anatomists—interested themselves in the structure of not only this animal but the Echidnas as well, and little by little its morphology came to be known. It was found to be largely mammal, but with no little reptile and bird in its organization. Its breasts were found to be rudimentary in structure and function, as compared with those organs in the higher mammalia, and this led to zealous efforts on the part of many enthusiastic zoologists to solve the problem of the nature of the creature's reproduction. For a long time it was thought that the young were brought forth at a very early stage of their development, and cared for by the mother in a nest at the further extremity of the burrows they excavate in the banks of the rivers where they lived.

Soon some colonists started stories about its *laying eggs*, and this version was spread by good observers who had studied the Australian fauna. However, zoologists, always more or less skeptical in such matters, persistently denied these reports up to the year 1884, when Mr. W. H. Caldwell, who had been at work on the subject, authoritatively announced that the Platypus was an oviparous mammal, and laid from two to four

Fig. 17—Duck-billed Platypus of Australia (*Ornithorhynchus paradoxus*); male, reduced. After W. Saville-Kent, F.Z.S.

eggs to the clutch—usually two—in a rude nest at the end of the burrow it dug in the river-bank. These eggs are about half an inch across and three-quarters of an inch long, the shells being white, tough and flexible, or something after the order of a sea-turtle's egg. This settled the question for all time, and later on it was announced that but one species of the Platypus now existed; no fossil forms have as yet been brought to light. Moreover, it has been pointed out that the frill-like arrangement at the base of the bill of the animal is intended to protect its eyes, when thrusting the implement into the mud in search of food, by limiting the distance it can go before being interrupted. Strangely enough it has also been ascertained that *true* teeth only occur in the young, where they are of the temporary sort—the teeth of the adults being of a species of horny substance, something like a beak, only tougher.

It is a remarkable fact that we find in our country fossils of very ancient mammals (tertiary) that possessed teeth corresponding very closely with these provisional teeth of the Platypus; but this must not mean that the latter may be regarded as a near prototype of any ordinary mammals, as everything points to its being a very exceptionally modified animal. Still, it will be more than interesting to study fossil forms of *Ornithorhynchus*, should they ever come to light and science obtain possession of them.

Male Duck-bills are generally larger than the females, having a length of nearly twenty inches; they are darkish brown on the dorsum, and somewhat paler on the lower parts, the hair being rather peculiar in structure, and there is a close under-fur present. External ears are absent; the small eyes are dark brown, and the external openings of the nostrils are near the end of the beak. In addition to these several curiosities of structure, Platypus possesses large pouches in its cheeks, like those found in many of our pouched rats and squirrels and it is likely they use them in a similar manner to carry food. The nails and webs of the feet may be *folded back* on the palm when the animal brings its short, strong limbs into use for burrowing or walking on terra firma.

Finally, to the top off the list of anomalous structures in the organization of this most curious form, we find that it has, on the heel of the male, a movable, horny *spur*, which is finely pointed, curved and strong. Upon examination it is found to be attached to the accessory bone of the tarsus, and normally curves upwards and backwards. Each spur is about an inch long and presents a minute, longitudinal groove extended to a slit at the apex. This groove or canal is intended to transmit the secretion of a gland situated on the posterior aspect of either thigh, close to the base of the spur, a duct passing between the groove of the latter and the gland, which is of some considerable size. Any person having a knowledge of animals and regarding this entire arrangement for the first time, is at once reminded of the fangs and poison gland of any of the venomous snakes, and, for one, I not only believe the apparatus is analogous but a true weapon of offence.

As long ago as 1876 Mr. Spicer gave us, in the *Proceedings of the Royal Society of Tasmania*, a case that supports this opinion, the details of which will be found on page 162 of the issue of that publication. A curious thing about this spur is, that we find it in the young of *both* sexes; but it disappears in the adult female, and this would seem to indicate that it was a weapon of both offence and defence for the males during the breeding season. It is also known that these spurs in the male are used for the purpose of clasping the female during intercourse at that season, of which use there are similar examples in analogous structures in other animals.

Mr. Saville-Kent, however, gives us an account, based on his personal cognizance on the Murray River, on the Victorian and New South Wales boundary. He says that "a young fisher-lad, on taking up his nets, found a half-drowned platypus entangled in them, and, while disengaging it, it convulsively gripped his hand between the two spurs, the point penetrating deeply into the flesh on either side. The result was a festering wound that refused to heal for many months, and for such time entirely deprived the lad of the use of the hand."

Mr. Saville-Kent also tells us that the "fur of the platypus, dressed so as to remove the outer and longer series of hairs, nearly resembles that of the fur-seal in both color and texture, and as a rare local product is highly prized for the manufacture of carriage rugs and other articles."

Almost entirely nocturnal in its habits, the Platypus is extremely shy and retiring in its general behavior, and owing to these circumstances, the naturalist may be in the region where they are comparatively abundant for a greater or less length of time before he is so fortunate as to see one; as a matter of fact, they are always considered a prize by the zoological collector.

In regard to the burrow that the *Ornithorhynchus* excavates, it may be as long as fifty feet, though it is usually less than that in length, while the fact that it has a double entrance to it is never departed from, the one being on land and the other under water. Weeds and fibrous roots are the materials they use to construct the loose nest they build at the terminal end, and these burrows are used as much for places of retreat, in case of danger, as they are for breeding purposes. Sometimes, if the animal is swimming—it being a most excellent swimmer—and something alarms it, it will promptly dive and repair to its burrow through the subaquatic opening; if on land under the same circumstances, it runs into the terrestrial entrance, which is usually to be found at some distance from the water, and in a dense patch of brush concealing it.

When asleep—or about to go asleep—the Platypus rolls itself up into a ball like some of the armadillos to be described subsequently, and in doing so draws the feet and tail over the abdomen entirely out of sight. The young ones do the same thing and curious little fur-balls they look like when in that shape.

Transportation of these animals to the zoological gardens of Europe has always been a problem, and only rarely successful. They have, however, thriven in especially prepared ponds and pools in the Gardens at Melbourne, having been quickly transported there after capture—an additional advantage in the problem of transportation. Competent naturalists have, at different times, carefully studied the Platypus in confinement,

[1] The Platypus and Echinas are considered by zoologists to constitute a subclass of mammals, very distinct from all the rest of the Class; while strictly speaking they are not true mammals at all, as they do not nurse at the breast their young, but lay eggs like some sauropsida (Birds, Reptiles). However, this is a point which cannot be properly discussed in this place, interesting though it is.

Dr. George Bennett of Sydney having been particularly active and productive in this matter of research. He captured at one time a pair of half-grown young, and kept them for several weeks as pets, and he tells us that he found them most interesting ones. They played like puppies, biting his fingers in fun, and rolling over each other in similar fashion. Strange to say, they were great climbers, and fond of scaling anything in the room that it was possible to climb up on. Their sleeping habits are irregular; though most nocturnal, they will also come out in the daytime of their own accord, sometimes singly and sometimes all together. When annoyed they growl exactly like little puppies, which is very amusing.

Mr. A. B. Crowther says that they "soon become very tame in captivity; in a few days the young ones appeared to recognize a call, swimming rapidly to the hand paddling the water; and it is curious to see their attempts to procure a worm enclosed in the hand, which they greedily take when offered to them. I have noticed that they appear to be able to smell whether or not a worm is contained in the closed hand to which they swim, for they desisted from their efforts if an empty fist was offered."

Some of the early accounts of the Platypus are very amusing, for at first the specimens, when brought to Europe, were pronounced to be "manufactured monsters" or "fakes," as they are now designated. It also bore various native names, as the *mouflegong*, the *malangong*, the *tambreet*, and so on. Although its habits and anatomy are now pretty well known, we are yet a long way from being in possession of *all* that is to be learned about this one of Australia's attractions.

As already stated above, the only other mammals in the world's fauna that lay eggs are the Echidnas. The habits of these curious species—for it has been said there are three different kinds of them—are similar; so what is told of one is more or less true of them all. The Australian species is probably the best known form, and the other members of the family are the Short-spined Echidna (*Echidna setosa*) confined to Tasmania, and the *E. bruijnii*, a mountain species of N. E. New Guinea. The genus is now generally known in science by the name of *Tachyglossus* (Illiger).

A common name for the Echidna is the Porcupine Ant-eater or, as they know it in Australia, simply the "Porcupine." Of this species Flower says: "In size and appearance it bears a considerable resemblance to the hedge-hog, its upper surface being covered with strong spines directed backwards, and on the back inwards, so as to cross each other on the middle line. The spines in the neighborhood of the tail form a tuft sufficient to hide that almost rudimentary organ. The head is produced into a long tubular snout, covered with skin for the greater part of its length. The opening of the mouth is small, and from it the Echidna puts forth its long slender tongue, charged with a viscous secretion, by means of which it seizes the ants and other insects on which it feeds. It is entirely destitute of teeth. Its legs are short and strong, and form, with its broad feet and large solid nails, powerful burrowing organs. In common with the other monotremes, the male Echidna has its heel provided with a sharp, hollow spur, connected with a secreting gland, and with muscles capable of pressing the secretion from the gland into the spur; but as the animal has never been observed to use this in defending itself, the spur probably serves some other purpose than that of offence or defence."

As in the case of the Platypus, the Echidnas are all nocturnal animals, being very active after dark, but sleeping away most of the day. When attacked it behaves like some of the armadillos, for it either commences to form a burrow with marvelous celerity to hide itself in; or, if the attack be too sudden for this, it rolls itself up into a round ball, and depends on its spiny coat for defence. When one is captured, it can easily be carried about by one of its hind legs, being careful not to allow the spur to reach your hand, or its spines the side of your leg.

They eat a good deal of sand and mud with their food, and in confinement are extremely uneasy and restless—a state that is made manifest by the captives making constant efforts to conceal themselves by digging a burrow.

The New Guinea form has only three toes on each foot instead of five—another anomalous feature of these extraordinary creatures.

In Australia and Tasmania the Porcupine Ant-eaters have frequently been kept in the Gardens, and it is not long before they become thoroughly reconciled to captivity. Many most interesting stories have been published about these creatures when thus kept; but our space will not admit of repeating any of these here. It may be said, however, that some of the most interesting and valuable of these are from the pen of Mr. Saville-Kent, who kept a number of them as pets while he resided in Tasmania. This eminent naturalist and photographer of living animals says in one of his writings that "The Echidna usually produces only one egg at a time; it is relatively small, not larger than a sparrow's egg, but equally and obtusely rounded at both extremities, and with a white leathery shell like that of a reptile. For some time previous to hatching, this egg is carried in a skin-fold or rudimentary pouch in the parent's abdomen, much similar to that possessed by many of the marsupials. The young one is also retained in this pouch for some weeks after escaping from the egg. When finally leaving the pouch, it is between three and four inches in length, and the spines are in an altogether rudimentary condition."

Some collectors have succeeded in fetching live Echidnas to England, and the Hon. Walter Rothschild has had not only the common species, but the rare 3-toed New Guinea species at his wonderful garden at Tring.

As in the case of the Platypus, no fossil remains of the Echidnas have been found that have thrown any light upon their origin and early affinities.

"Among bones of extinct Marsupials of Pleistocene age from the Darling Downs," says Flower, "Mr. Krefft found a portion of a humerus of an Echidna, considerably larger than the existing Australian species, which he has named *E. oweni*."[2]

They are probably types of great antiquity, and I am inclined to believe that sooner or later some one will be so fortunate as to discover fossil remains of animals linking them to their ancient ancestral stock. As it now stands, we have no hint as to what sort of animals connected them with either the lower vertebrates or the higher mammals.

[2] *Ann. and Mag. Nat. Hist.*, 1868, Vol. I (Ser. IV) p. 113.

The Limitations of Standardized Shipbuilding*

THE following observations on the subject of standardized shipbuilding and its limitations are not intended to apply to these times of stress when the great problem is to turn out as many cargo carriers as possible, irrespective of their absolute suitability for any particular purpose for which they may be employed. Considerations of their commercial efficiency are now subordinated to quick output of tonnage, and rightly so. Undoubtedly the best solution of this war-time problem is to fix upon a few designs that can accommodate themselves to the various classes of cargo which are allowed entry, with due regard to the restrictions of draught, quay space, etc., imposed by harbor facilities, and to standardize these designs as far as is practicable:

In this connection it is observed that, from a national point of view, it is better to carry a given amount of cargo in two ships than in one of twice the size, as in the former case it would take at least two torpedoes to sink the entire cargo, whereas in the latter one would probably suffice. Obviously, this cannot be carried to extreme limits, but such a view should meet the objection of some critics at this time, who point out the apparent waste of facilities in some of the yards now constructing standardized vessels, where it has been necessary to lay down 400-foot ships on berths that would accommodate vessels of 600-foot or more.

In normal times, however, considerations of commercial efficiency must arise. As to the manner in which these considerations affect the design of ships we cannot do better than refer to the findings of the Dominions Royal Commission of three years ago, which inquired, among other things, into the problems of the economic size and speed of steamships and development of harbors; for, after all, the determining factors at the present day are the harbor facilities. The findings of the Commission were summarized in these columns at the time. (*The Shipping World*, January 14, 1914.) They were based upon memoranda prepared by Lord Pirrie and Sir John Biles, both of whom are recognized authorities on these subjects. Some of the main points that emerge from their considerations are, that for economic working:

(1) The cost of carriage per ton mile is approximately reduced in the direct ratio in which the draught of a vessel is increased, the speed being the same.

(2) The economical speed of a vessel increases with increased size and draught.

(3) Shipowners will do their best to ensure that the size of the largest and newest vessels is always such as will take advantage of any harbor development of which there is a reasonable prospect being made.

(4) The size of steamships is increasing.

In other words, the evolution of the most economical merchant ship is still going on. It must not be presumed that there is no finality in this. There are limits of size above which a ship engaged in any particular trade would become less economical. Considerations of volume and regularity of trade have also to be taken into account. On the whole, however, we are safe in saying that there is not as yet any finality. And we must leave it to each individual shipowner to say what type of ship is best suited to his particular trade. Each type has to be treated differently. A ship that has to carry heavy cargoes stowed well down in her holds will be greatly different from one that has to carry general cargo and perhaps deck loads.

These remarks apply more particularly to vessels running in fixed trades, and not with such force to ships of the "tramp" class, which have to seek their cargoes in all parts of the world. In these boats the main requirements are a useful and handy size, well equipped with cargo-handling gear, so as to be practically independent of port facilities. Such cases should lend themselves to standardization, although even here it may be remarked that the tendency is more and more toward regular lines of steamships plying between fixed ports.

For standardization to be of any use it must be possible to fix on a few forms of average dimensions. Details of hull construction must be so arranged that all the firms building to a design must have the necessary facilities. In other words, they will be governed by the worst equipped firm. For example, the weight of any unit of the hull must not exceed the lifting facilities of any one firm. Even then it is practically certain that each firm would want to work on its own lines according to its plant. The writer was discussing this problem with a shipbuilder who has some of the standard boats on hand at the present time, and who informed him that his firm was getting out all its own construction details. In this case the firm is no better off, excepting for being able to get the material, than when building to a set of lines supplied by the owners; in which case the ship has passed the design stage only. Anyone with experience of building on these lines knows how often the firm wishes to depart from the specifications.

For a shipowning concern of any size, rather than pin their faith to cheap standardized vessels, it would pay them to employ a competent naval architect, who would familiarize himself with all the practical conditions and limitations imposed by the kind of cargo carried and port facilities. Money thus spent would be recovered many times.

The Shipping World (London).

Behavior of Cement in Water Containing Sulphuric Acid

SHORT cones were made from two Portland cements, an iron Portland cement, a mixed cement, and five blast-furnace slag cements respectively, both from the neat cements and from mixtures with sand in the proportion of 1:2.5. After 36 days' storage under water, in air, and again under water, the test pieces were kept for 14 days in water containing 1 per cent free sulphuric acid, then, for the same time, in a solution of 1.2 per cent and finally for three months in a 1.5 per cent solution of sulphuric acid. The Portland cement test-pieces blistered, owing to the formation of gypsum; the cement-sand mixtures swelled badly, and some of them were badly cracked. The presence of trass or blast-furnace slag cements only delayed the destructive action of the acid. Test-pieces made with blast-furnace slag cements were more resistant to the acid. After four months, the pieces of pure cement were covered with a smooth, white, hard coating of gypsum, which protected the interior, and the cement-sand test-pieces retained their form and structure fairly well. The iron Portland cements were more strongly attacked than the others. The author admits that the acid solutions used were stronger than those likely to come into contact with concrete under ordinary conditions, but considers that these tests show that blast-furnace slag cements have a greater resistance to acids than Portland and iron Portland cements.—Note from the *Journ. Soc. Chem. Ind.* on a paper by H. NITZSCHE in Amierter Beton.

Stock Raising in Madagascar

STOCK raising may be said to be one of the most important industries in Madagascar. The official figures show 2,300,000 head of cattle for 1904 and this rose to 6,000,000 in 1916. It is claimed that this amount of stock can be called upon for 10 per cent of the total in the shape of meat without danger of diminution, and this figures 600,000 head per annum. From this is to be deducted 80,000 head for food in the island and 20,000 in the neighboring islands of Mauritius, Reunion and others. At present Madagascar can thus supply 500,000 head. The average weight per head is 780 pounds. There are already five establishments in the island for the canning or the frozen meat industry, and the Havraise Steamship Company now has three steamers equipped with refrigeration holds for importation into France

The Equipment of an Army*

A Stupendous Work Shown by British Figures

VAGUELY, everyone has known that the task of supplying the Army with its equipment and food has been an enormous one. In twenty months the land forces have been increased from about 200,000 to the present millions. How the system that sufficed in August, 1914, for the existing service has grown and adapted itself to meet the ever increasing developments will be, whenever it can be told, one of the most wonderful chapters of the history of the war. At present, that full tale cannot be recorded, but the time has now come when it is permissible to give some particulars of the mighty work that has been achieved, and the new conditions which British manufacturers met and satisfied. It constitutes a narrative of the happiest coöperation between the War Office, the great industrial enterprises, and the workers —men and women—and is one of which the whole Empire can be unreservedly proud.

There were good and sufficient reasons for not revealing all the magnitude of the nation's needs and transactions at an earlier stage. It was clearly undesirable to permit information to come out that would result in unduly enhanced prices not only to the War Office, but to the civilian population. Not until clear knowledge of the reserves of raw material, the machinery available, and labor conditions could be tabulated would it have been possible to estimate the prices that the country would have to pay. To have given general ideas as to the magnitude of the contracts to be called for would probably have resulted in vastly increased demands.

Mistakes of this kind have been marvellously well avoided. Huge, almost unthinkable, additions to the output of clothing, equipment, tools, and the rest have been made, and though, of course, the cost has risen, the increase has been far below what might have been expected. While the production in many departments of industry has been multiplied literally some forty, some sixty, some a hundredfold, in view of Army needs, there has still been no scarcity so far as the non-fighting community is concerned.

THE QUESTION OF CLOTHING

To plunge forthwith into figures that fairly stagger the imagination, let it be said that during the first twenty months of the war the amount of woolen cloth required has been 90,000,000 yards, which would suffice to put a girdle twice round the earth. Of the flannel required for shirts and so forth the amount has been nearly as great, and totals 88,000,000 yards. So far as contrasting these huge totals with the normal requirements of peacetime, there is the safe and sure standard of the last census of production issued in 1907. And this is how the table works out, if requirements for the Allies as well as for our own Army are included:

MATERIAL

Article	Annual average in peace years Yds.	Total Aug. 1914, to March 31, 1916 Yds.	Ratio of requirements for 12 months of war to peace average
Cloth, woolen, worsted	1,149,000	117,000,000	61
Flannel	1,234,000	84,000,000	41
Cloth, cotton	632,000	194,000,000	175

To understand, however, more clearly what this implies in regard to the country's industry is, it should be understood that the war requirements cover a period of twenty months. Taking twelve twentieths of the amount shown in the second column, we have, roughly, the requirements of twelve months of war to compare with the average demands of peace time. The ratio is given in the last column, and does not represent an increase in percentages in the way most of us are accustomed to think. It means actual multiplication, and that the demand on British industry for flannel has been increased 41 fold, for woolen and worsted tissues 61 fold, and for cotton tissues 175 fold. Of these textiles the Allies have taken the largest share in the case of woollens and cottons. Over 25 per cent of the woollens and worsted, and over 20 per cent of the cotton textiles, have been, or are being, manufactured to meet the requirements of the Allies.

In the matter of value the figures are impressive. The census of production returned the entire annual output of flannels and delaines as being 48,473,000 yards, worth £1,774,000. The requirements of flannels in twenty months of war have been for 84,000,000 yards, of an approximate value of £6,750,000. Put in another way, this means that the output has been 75 per cent more than, and between three and four times the value of, the entire output of delaines and flannels in 1907. Compared with our entire export trade in these fabrics in the year preceding the war, which was 7,718,000 yards of a value of £300,000, the total is indeed astonishing. In no branch of industry was the strain more acute, but in all the great centers of these industries the utmost efforts were put forward to supply deficiencies. In the Colne Valley the visitor was told of mills that ran tirelessly night and day for weeks to supply the pressing needs.

*London Daily Telegraph.

SUPPLYING THE UNIFORMS

After securing the khaki worsted tissues and the flannel, there was the question of making them up. The materials have been supplied to contractors (who to some extent supplemented the Government materials by what they provided themselves), and they have made from them uniform and shirts. Of these latter something like 26,000,000 have been required for ordinary, field, and training wear, apart from the further huge total demanded in the hospitals. For it must be borne in mind that the soldier, whether in training camp, the trenches, and all phases of active service, wears out his clothes very rapidly. It may give a comprehensible idea of the constant replenishment that has to go on steadily to say that the Army now calls for nearly as much clothing in a week as it formerly did in a year.

And it is not only the very big items that constitute difficulties. Buttons, for instance, may seem but mere accesories, yet they have in the aggregate constituted a very important commercial asset. Something like 840,000,000 of them have been required in their various forms since the war began, which, as it is pointed out, is about equivalent to a dozen and a half for every man, woman, and child in the United Kingdom. You are tempted then to speculate on the ratio that has been distributed or taken in the form of souvenirs by the soldiers' friends and admirers.

In the actual work of making up, the Army Clothing Factory, strained to its utmost output, was quite unable to meet the requirements that began to be felt the moment that the Expeditionary Force made ready to leave for France. The great clothing contractors of London, Leeds, and elsewhere were called upon to meet these urgent wants, and for many months the Factory Acts had to be suspended to fulfil the urgent and necessary labors. In the factories the work was highly specialized, and as ordinary trade declined and women and the male civilian population bought less in the way of clothing, the labor problems, especially in regard to tailoresses and blouse makers, adjusted themselves by meeting the military requirements. The dreaded spectre of unemployment which the Queen's Work for Women Fund was intended to combat passed entirely, and there was more work than workers.

Another table will show some of the amazing totals that have been provided:

Article	Annual average of orders to the trade in peace years	Total Aug. 1914 to Mar 31, 1916	Ratio of requirements for 12 months of war to peace average
Boots, pairs	227,000	21,750,000	57
Jackets, service dress	78,000	11,490,000	88
Trousers, service dress	92,000	11,004,000	72
Frocks, khaki drill	58,000	1,134,000	12
Trousers, khaki drill	73,000	1,167,000	10
Pantaloons	13,000	2,507,000	116
Greatcoats	34,000	4,836,000	85
Caps, service dress	222,000	11,088,000	30
Socks, pairs	980,000	54,684,000	33
Cardigans and jerseys	77,000	7,555,000	59
Drawers, woolen and cotton	194,000	23,144,000	72
Vests	.....	8,855,000	...

BOOTS AND HOSIERY

The new situation in regard to boots is extraordinarily interesting. In the vast total quoted, ordinary marching boots are alone referred to, and the millions of pairs of canvas shoes and slippers for hospital wear are not included. The industry of Northampton, Kettering, Leicester, and the other centers was unprepared for the new demands, and only the most careful organization and amendment, by an expert, of the specifications has made it possible for the British manufacturer to undertake with safety, in addition, huge orders on behalf of the Allied Governments. Of the enormous number already mentioned some 16 per cent were ordered for or supplied out of stock to Allied Governments, but it does not include the 7,000,000 pairs in course of making for the Russian Government. The value of boots alone, apart from shoes and slippers, demanded from the British trade in the twenty months of war would come to something like 90 per cent of that of all the boots, shoes, and slippers manufactured in the United Kingdom in 1907. It is absolutely essential to keep a large stock of footgear in order to provide for emergencies, and a proportion is set aside for this reserve for future consumption. In boots, as in the other details of clothing, the Army requires for refitting every week sufficient to supply entirely the male population of a great town or one of the larger metropolitan boroughs.

Socks and hosiery presented great difficulties in the autumn of 1914. The Queen, who was consulted by Lord Kitchener on the subject, took a step that was of real value in relieving the strain on this branch of industry when she appealed, at the end of September, 1914, for 300,000 belts and 300,000 pairs of socks from the women of the Empire. That quantity was more than forthcoming—indeed, the total of the two items reached 970,000, or nearly equal to the whole demands of the pre-war Army. In the breathing space thus gained the manufacturers could secure and put up the additional machinery required, and to turn out the almost incredible total of 54,684,000 pairs of socks and 8,855,000 vests, or at the present moment nearly 9,000,000 of these last, which is not a normal issue in peace time. The Allies have taken some 14 per cent of the socks and smaller proportions of the other articles, as caps. To summarize briefly what these figures mean as regards the conditions of two years ago, it may be said that for the more important items of uniform clothing the demands on trade have increased seventy to eighty-fold, and for hosiery from thirty to seventy-fold.

These requirements have naturally thrown exceedingly heavy demands upon their manufacturers. Again, to cite the Census of Production, the entire output of hosiery for the United Kingdom would average in value £8,445,000. Including such further items as between nine and ten million pairs of woollen gloves, and 13,000,000 "can comforters," the total value of the hosiery demanded from the industry in the United Kingdom for military exigencies during twenty months of war exceeded this value by some 45 per cent. These heavy calls, and the increase in the cost of wool, have, of course, meant higher prices, but even at the rates that were paid before the war value would have been appreciably higher.

BLANKETS AND TENTS

Another important detail of equipment for which the country was totally unprepared was in regard to blankets. Moreover, it will not be forgotten how the late Sir George Pragnell and some other magnates of the wholesale warehouses of the city circumvented an unscrupulous effort that was made to corner these essentials. In the early autumn of 1914 all sorts of makeshifts had to be resorted to, as cutting up and hemming squares of heavy coatings. But here again British energy and resource soon made headway, and met the urgency of the situation. The actual figures are:

Article	Annual average in peace years	Total Aug. 1914 to March 31, 1916	Ratio of requirements for 12 months of war to peace average
Blankets	139,000	19,800,000	86

Here the claims on industry, it will be seen, have multiplied eighty-six-fold. The 1907 output of blankets numbered 6,170,000, worth something over £1,455,000. The war requirements represent over three times the number and five times the value of a normal year. A further interesting point in regard to these blankets is that some 2,000,000 have been supplied to the Allies. The mills of the United Kingdom have produced 54,000,000 yards of tent-duck. This, as an ingenious statistician has worked out, would suffice for a marquee three and a half miles square. The tent-pins have numbered 33,000,000, but here comparison becomes impossible. No records exist of the numbers of tent-pins made in this country before the war.

FOR THE HORSES

It is frankly admitted that great difficulty was experienced in the early months of the war in obtaining from home resources anything like an adequate supply of harness and saddlery, and large orders for this were perforce placed in the United States. The difficulties are now being rapidly overcome, and it may be recalled that women were asked some fourteen months ago to come forward and take up leather work of various degrees. Up to the end of last March our own manufacturers had been able to undertake orders to the approximate value of £10,000,000. This, it is pointed out, is an exceedingly striking and significant figure, for in 1907, when, of course, the motor was well started on its dominance over the horse, the entire output of

saddlery and harness was about £1,800,000. This industry, therefore, in the twenty months under review has amounted to something like five times the entire output of the trade during the last period for which reliable information is forthcoming. But some standard of comparison becomes possible when it is realized that in the last financial year of peace (1913-14) the amount under the harness and saddlery vote was only £61,000. For twelve months of war, therefore, the figure already cited would give an expenditure of £6,000,000, or an increase in the ratio of little less than 100 to 1. Up to December 1 last contracts in saddlery to the value of £1,000,000 had been placed in this country for the Allies.

Perhaps it is hardly to be wondered at that we had sunk to a very low stage in the matter of the production of horseshoes. But the lost ground has been more than recovered. Instead of having to send orders abroad, we were able to say in November last that the outturn of this country had been increased five-fold, and in March last tenfold, while fifteen-fold is now in sight. In other words, not only are we self-supporting in this direction, but are able to help our Allies. The motor has played a great part in the war, but the horse is far indeed from being superseded, as may be judged from the fact that nearly 800,000,000 horseshoe nails and 140,000,000 frost-nails and cogs have been required so far. In the matter of forage, difficulties even greater than in regard to those of the men's commissariat have had to be faced, and it may be said have been most effectually dealt with.

CAMP REQUIREMENTS

In camp kettles and mess tins the demands have multiplied seventy-four and seventy-eight fold respectively. These are the figures:

Article	Annual average in peace years	Total Aug. 1914 to March 31, 1916
Camp kettles	8,000	982,000
Mess tins	73,000	9,450,000

Of the mess-tins about 20 per cent have gone to our Allies. Very careful organization was required to secure the necessary supplies of cutlery for the training centers and for the men in the field. About 23,000,000 knives and forks and 11,000,000 spoons represent the demands in this direction. Of the former production has been increased about threefold and of the latter five to six fold. Incidentally you learn that the production of clasp knives has been doubled. Brushes, for the making of which there was an appeal to women to come forward, have reached the huge total of 43,000,000. In that, of course, all sorts are included, whether the hard and soft, the long and short handled for sweeping, and those designed for scrubbing, cleaning, harness, clothes, and shaving. It constitutes, indeed, a tribute to the cleanliness and tidiness of the camps and the persons of the Army.

Barbed wire has been requisitioned by miles. It was an auxiliary of warfare which at first we were quite unable to supply in adequate quantities. But the production has now been trebled, and it is hoped will be quadrupled.

FOOD AND DRUGS

There are good and sufficient reasons at this juncture for not entering too closely into details as to the extent and sources of the food supply. The steady maintenance of the fare for the best-fed Army in the world is one of the wonders of the world, and when all can be told the real and scientific economics that have guided the whole system it will throw new light upon the knowledge of the world's resources and the way in which it has been used by men whose names even are unknown to the average citizen.

It may be said, however, without indiscretion, that the normal requirements for 1,000,000 men for a year on the British scale of rations come to some 365,000,000 pounds of fresh or frozen meat, or 274,000,000 pounds of preserved meat, 91,000,000 pounds of bacon, 68,000,000 pounds of cheese, the same quantity of jam and sugar, 22,000,000 pounds of condensed milk, and 14,000,000 pounds of tea. This number of men will further need 11,000,000 pounds of salt, 630,000 pounds of pepper, and 450,000 pounds of mustard. A further provision of tea and sugar, with pea-soup and the "tots" of rum, must be allowed on these totals when the men are in the trenches. Tinned and dried vegetables by the million pounds must be available to take the place of the fresh varieties where these cannot be obtained. Then a certain amount of alternatives, as rice in place of biscuits, or dried fruit and honey instead of jam, must be provided.

If these quotations be multiplied by the number of millions of men you think have to be supplied, some idea may come of the stupendousness of the provision required. To this add thought as to what it means to keep these in regular, cleanly, and attractive service, the millions of packing-cases, bags, tins, and jars that are necessary. It is easy to sit down and talk of freights and steamer shortage. But the stay-at-home person has no conception as to what is involved in the seaborne transport of the many necessaries we do not produce at home.

Again, in spite of all the magnificent supplemental work of the British Red Cross organization, there is a very big addition to the provision for the fighting men, in the "hospital comforts" for the wounded. The phrase implies meat extracts, tinned chicken and rabbit, cornflour and arrowroot, port and champagne, and very much more. And the country only desires that the best in abundance shall be provided for the men who have dared and done so greatly.

A word, too, may be added in regard to the supplies of drugs, though precise figures on this matter are not at present available. This country is now making better progress in the production of these than is generally realized, especially in regard to the synthetic compounds for which formerly we were dependent on Germany. This is notably the case in regard to the salicylates, as salicylic acid, salicylate of sodium, salol, methyl salicylate, and aspirin, which are all being manufctured in England now upon an extensive scale. Some of the leading universities and schools of science have also taken up the production of such local anæsthetics as novocaine and eucaine, and there is now no difficulty in obtaining them in sufficient quantities. Even salvarsan is now made in our midst.

Better organization has come into the supply of crude vegetable substances used in medicine. The Overseas Dominions are helping the Allies as well as the Motherland in regard to valuable plants that they can raise. Women, moreover, are helping in this direction, and the movement that has started under one or two associations for encouraging the growth of herbs and medicinal plants, with a system of collection and drying, is already proving its usefulness, and will do yet more in the future.

How the needs have been met as they have arisen would be interesting indeed, could it be told in detail. Great experts of various industries and trades have given their practical help wherever it has been needed. But behind them all has been the practical knowledge of the heads of the various departments involved, whose services in the nation's needs can never be overestimated. The growth of the Army in itself has been an amazement to ourselves, not to speak of the enemy. The expansion, however, would not have been possible unless all supplies could automatically grow with it. That this miracle was achieved in the quietest and most efficient manner possible is not the least wonderful aspect of the new spirit that the war has brought into the nation and the Empire.

A New Molybdenum Mineral

F. B. LANEY, of the United States Geological Survey, recently discovered a dark-green mineral rich in molybdenum, which occurs as an incrustation on specimens of ore from Vein No. 21 of the Lucania Tunnel, near Idaho Springs, Colo. Dr. Laney's examination of the occurrence, made in conjunction with the author, showed that the mine water, which percolated slowly from the vein in the immediate neighborhood of the green incrustations, contained a molybdenum compound that colored it a deep blue. This color was so intense that in several experiments in which the mine water was used as a writing fluid the writing was as legible as with an ordinary ink. The acidity of the water was pronounced and in some places where it had dripped upon the iron mine rails it had eaten them to a depth of three-quarters of an inch or more.

An analysis of a sample of this water by R. C. Wells, of the United States Geological Survey, showed the following results:

Analysis of mine water from Vein 21, Lucania Tunnel, Idaho Springs, Colo.[1]

Substance	Grams per liter
Molybdenum trioxide (Mo_3O)	7.98
Molybdenum dioxide (MoO_2)	Trace
Ferrous iron	2.01
Ferric iron	1.75
Aluminum	.27
Calcium	.50
Magnesium	.73
Sodium	.26
Potassium	.14
Sulphate (SO^4)	18.26
Chlorine (Cl)	.17
Hydrogen (of free acid)	.13

There is no doubt that the color of the water is due to a dissloved molybdenum blue, possibly ilsemannite, but just what the compound is has not been determined.

The blue mine water had impregnated considerable areas of the vein material in the drift on both sides of the main tunnel and immediately adjoining it. The rock was colored a light blue with the coloring particularly strong along the fractures in the vein material and in the more porous rock. Where the rock carrying the molybdenum blue had been exposed to the air circulating along the main tunnel and about the mouths of the drifts there was a powdery incrustation of the dark-green molybdenum mineral already referred to. Several specimens were collected where this incrustation was a yellowish or golden green and a few where it was almost a bright yellow. On the dump at the mouth of the main tunnel many specimens were coated with the green molybdenum mineral. The latter had seemingly been formed by the action of the air on ore that had been impregnated with the molybdenum blue.

Owing to the difficulty of obtaining reasonably pure samples of these blue and green minerals, and to the inherent difficulties in the analysis of compounds, whose state of oxidation is so unstable, their exact composition has not as yet been determined.

The molybdenum minerals described above are probably identical with those noted by Lindgren and Ransomea in a small vein east of the Howard flat vein in the Cripple Creek district, Colorado. However, the author believes that the green molybdenum mineral (relatively insoluble) is formed from the soluble blue compound, and not vice versa, as indicated by Lindgren and Ransome.—*Bulletin No. 111, Bureau of Mines.*

[1] The specific gravity of this water at 25° C. was 1.031.

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